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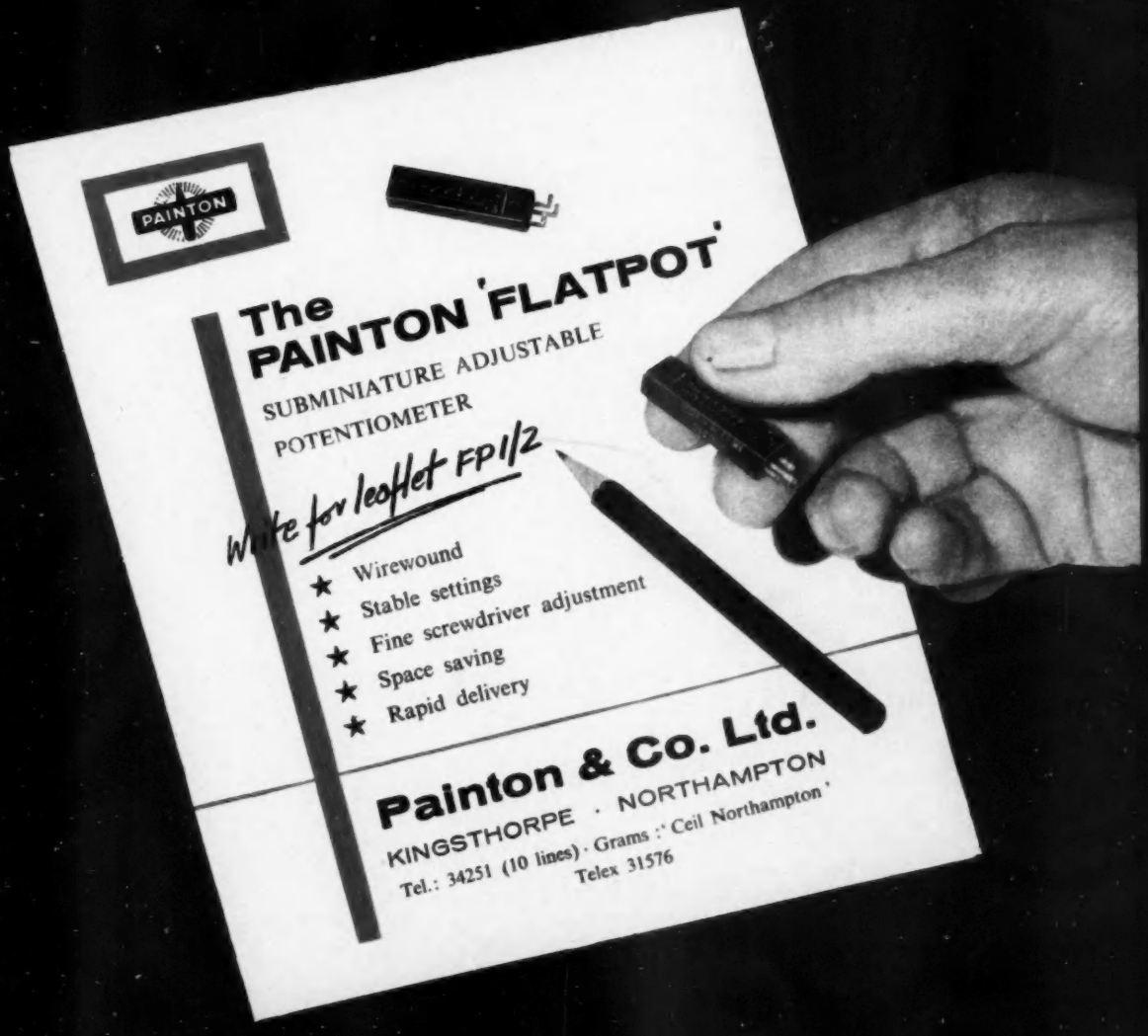

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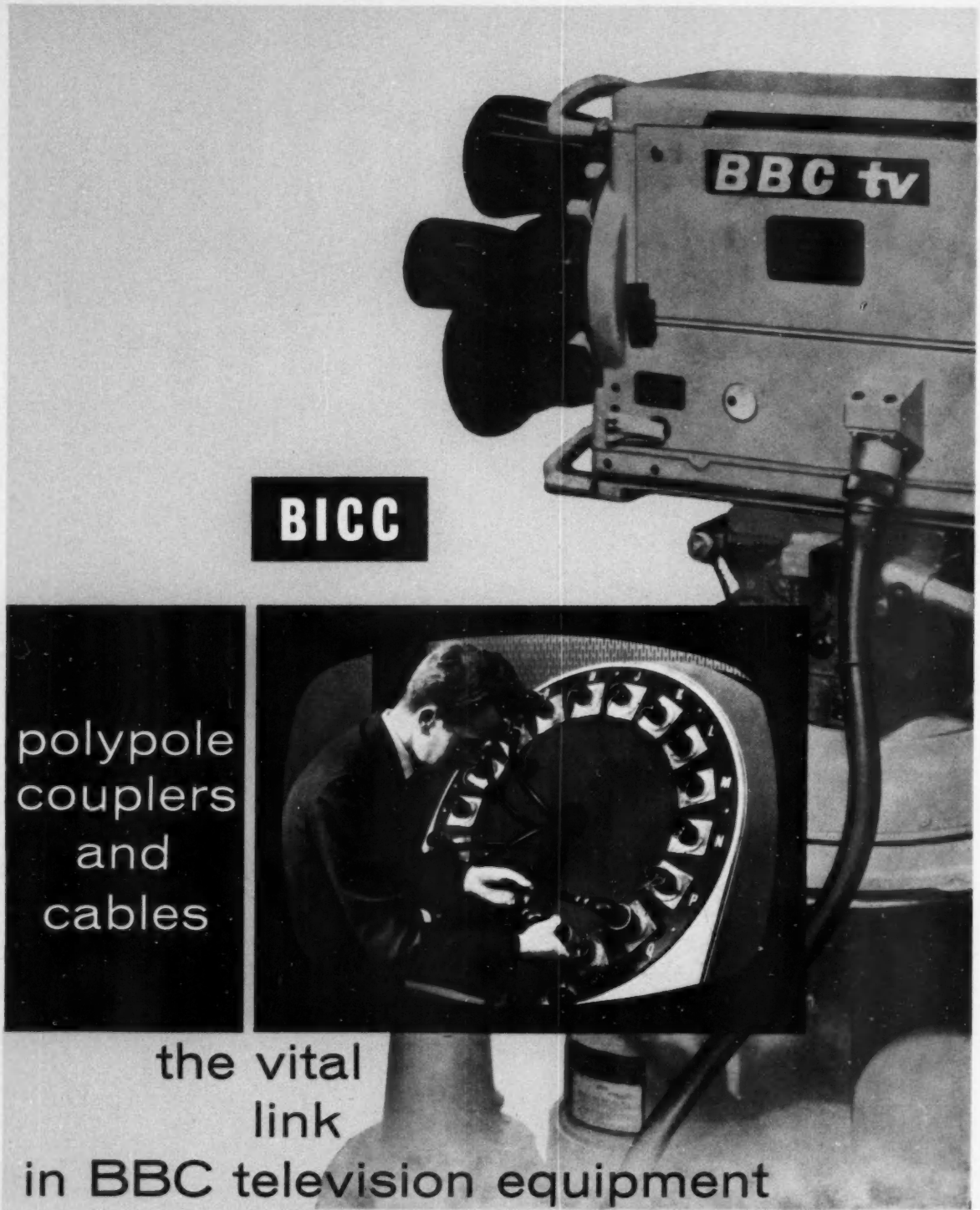

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Vol. 33 No. 398

APRIL 1961

Electronic Engineering

Incorporating ELECTRONICS, TELEVISION and SHORT WAVE WORLD

Managing Editor: H. G. FOSTER, *M.Sc., M.I.E.E., M.Brit.I.R.E.*

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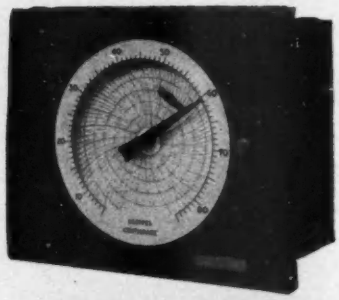

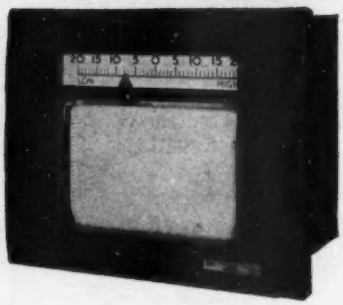

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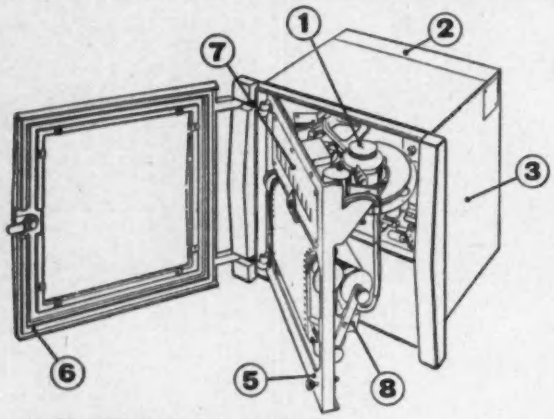

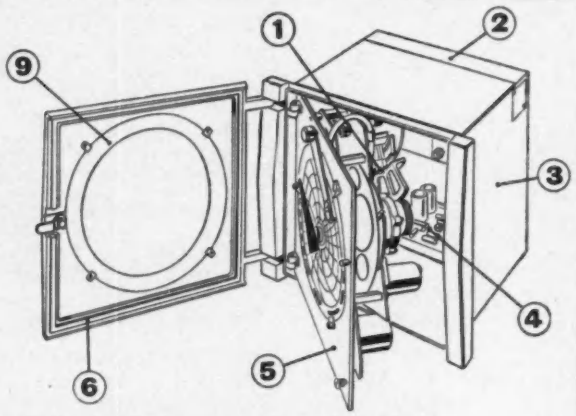

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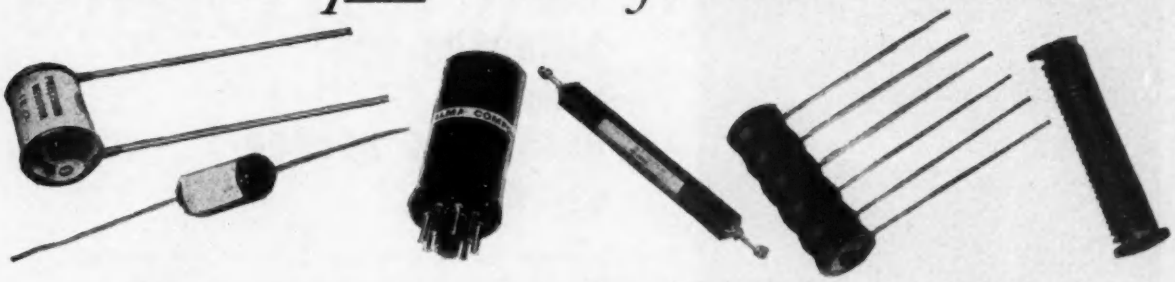

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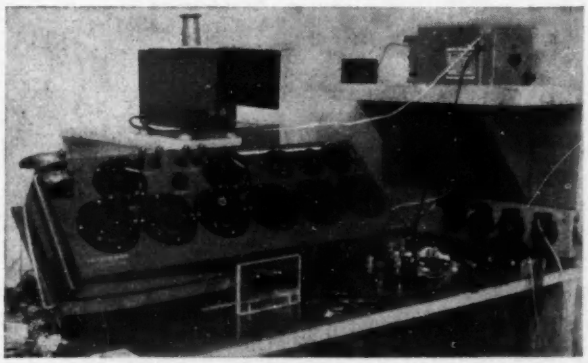

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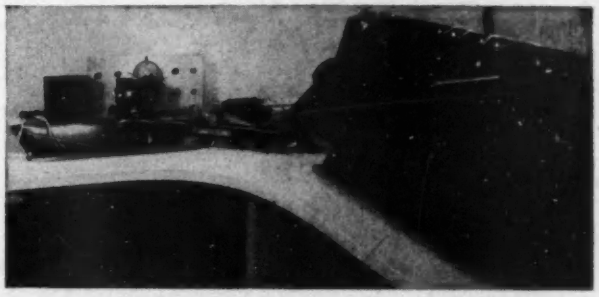

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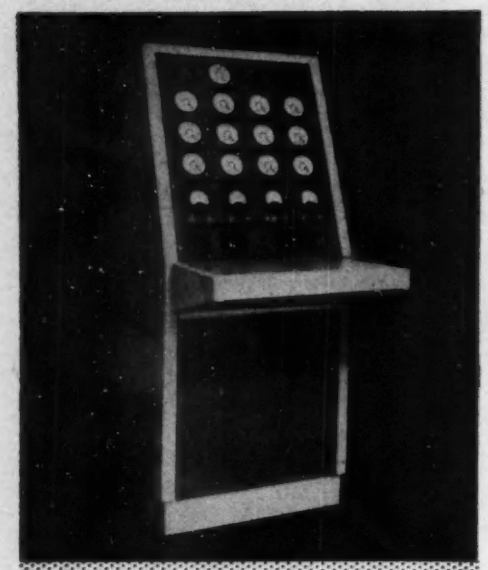

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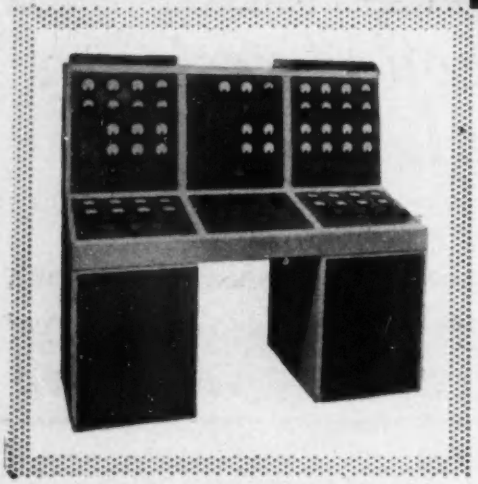

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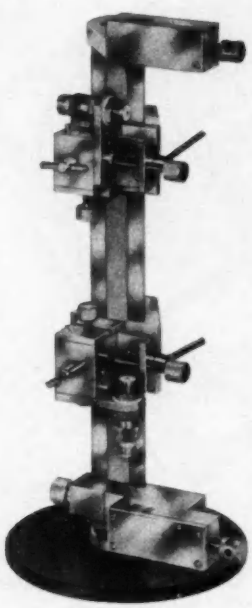

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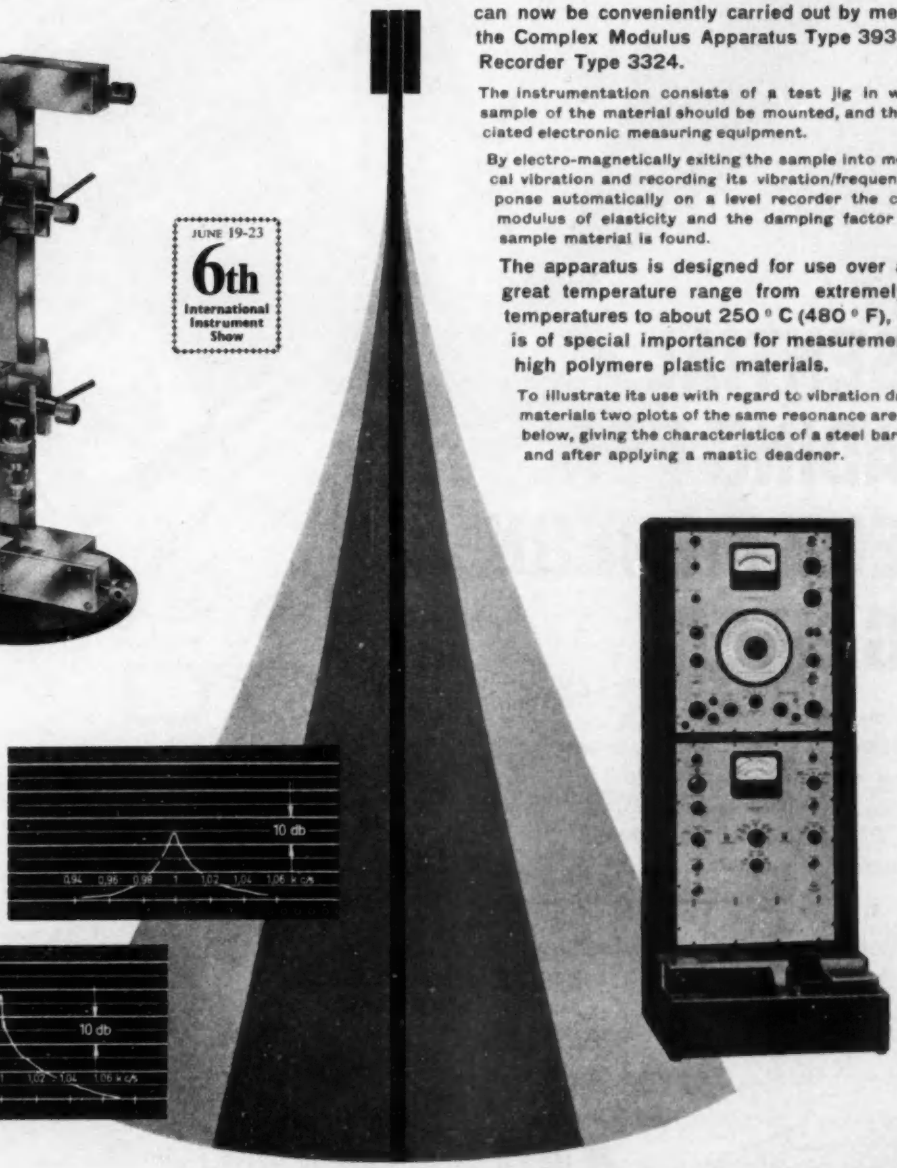

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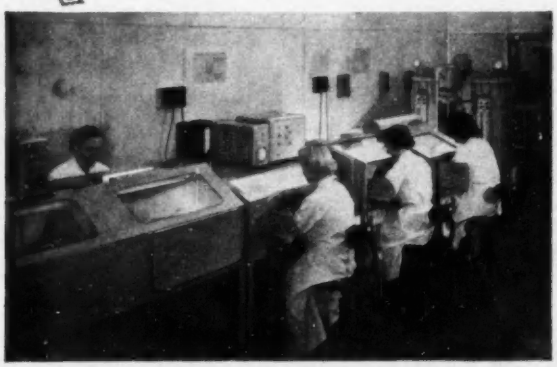

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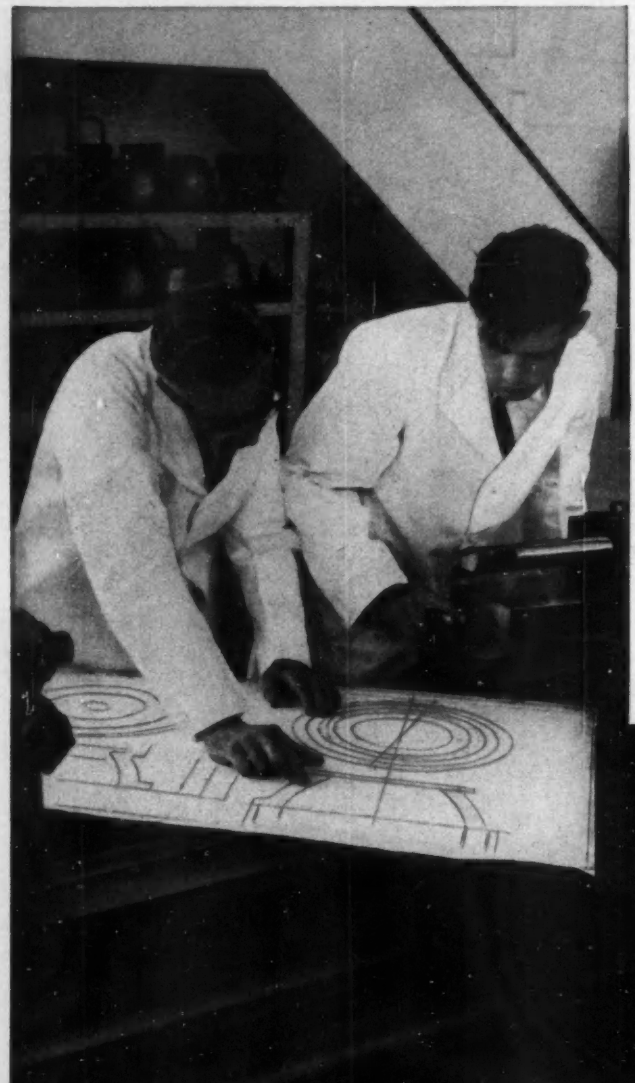

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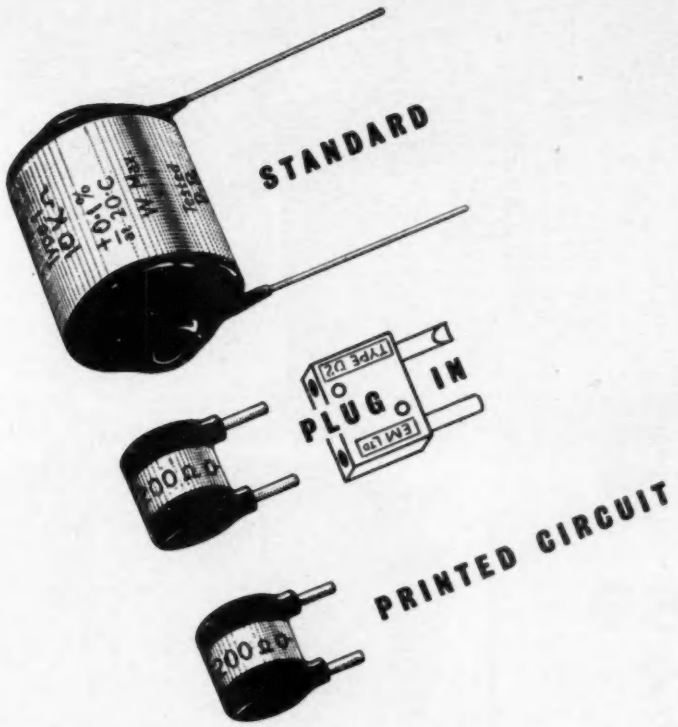

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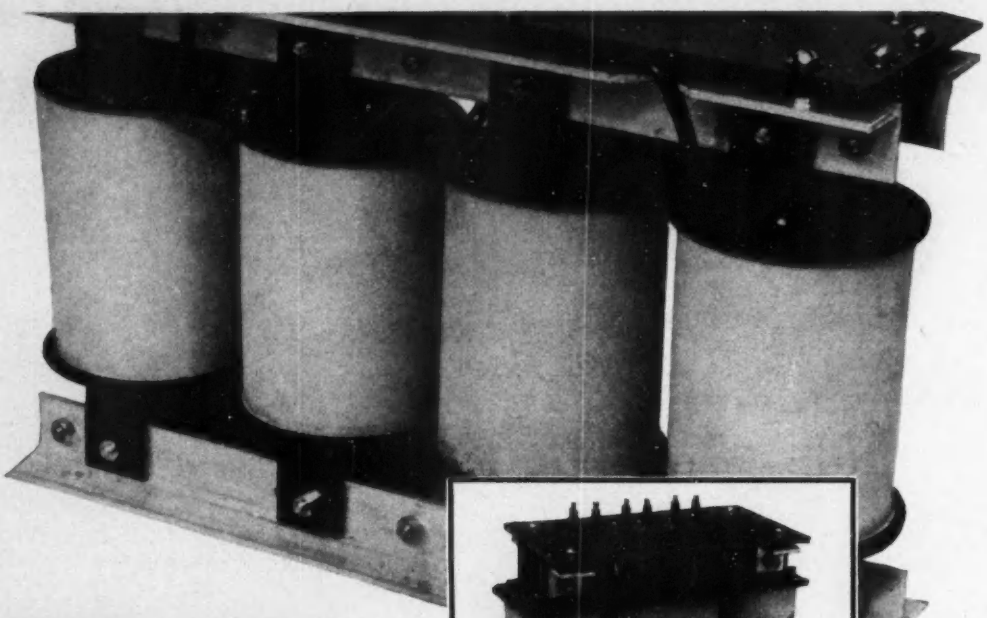

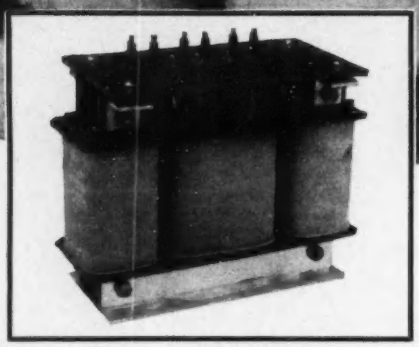

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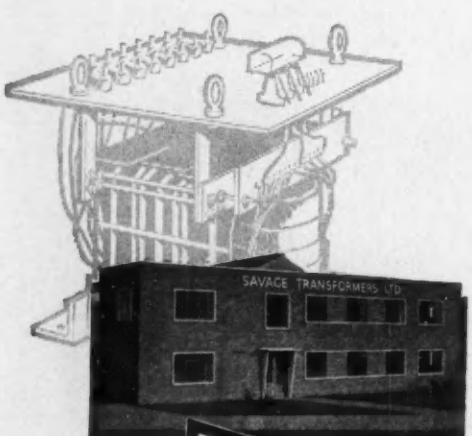

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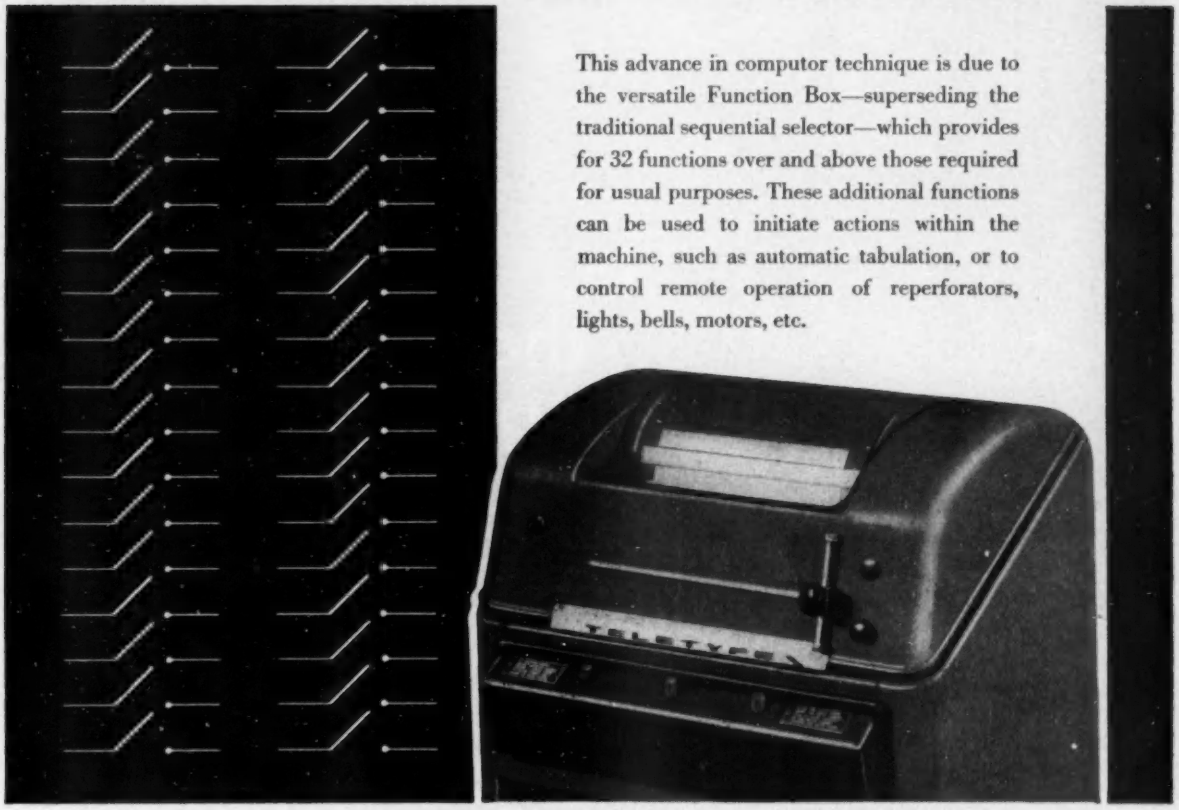

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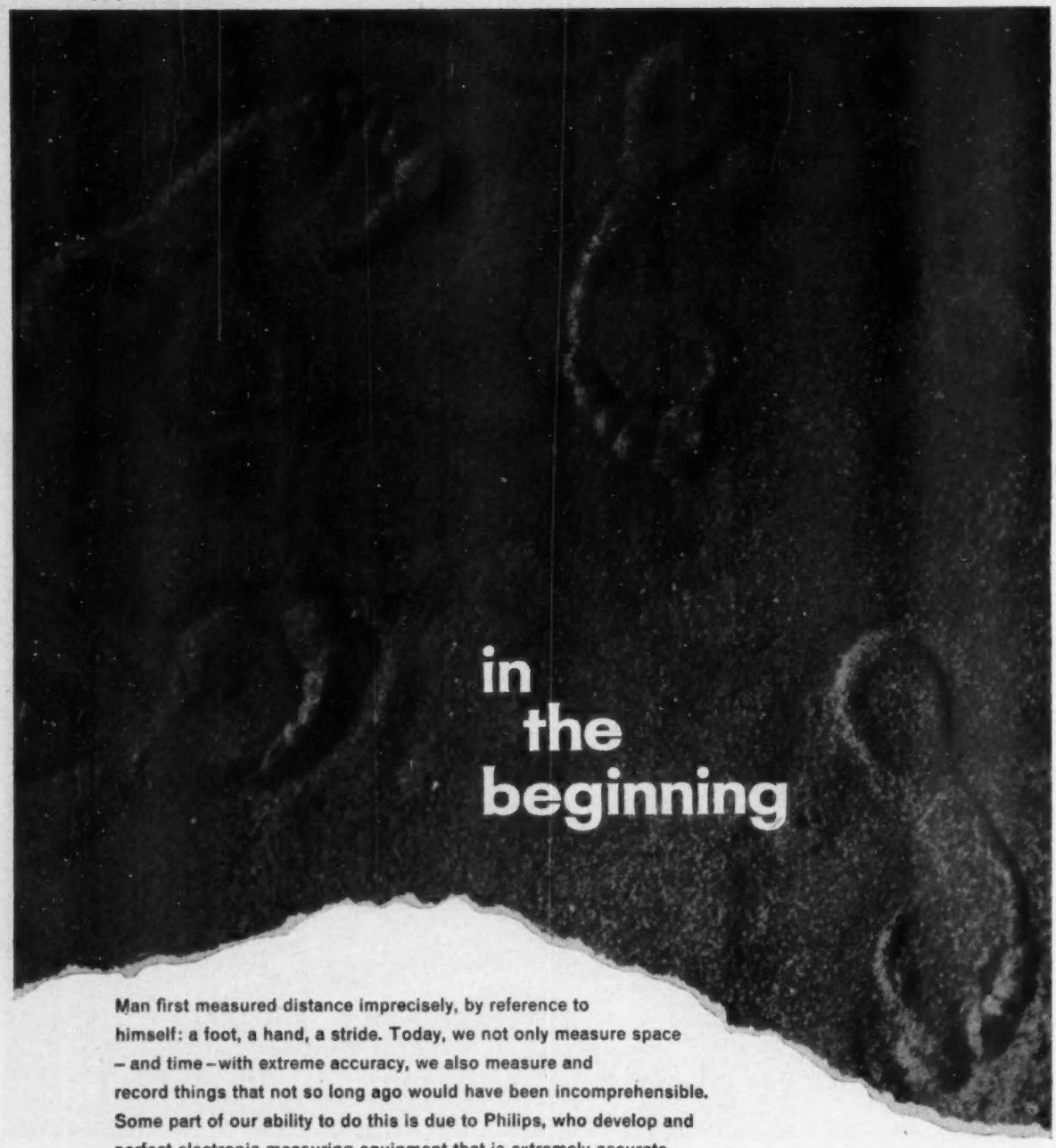

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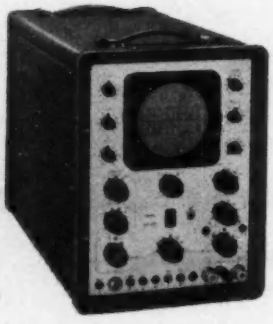

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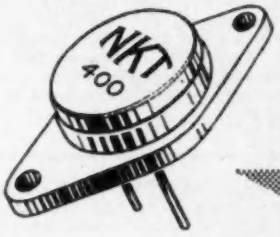

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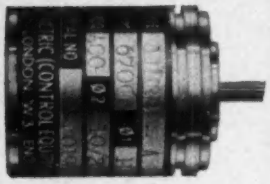

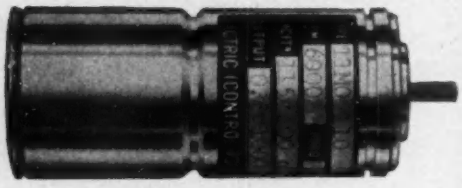

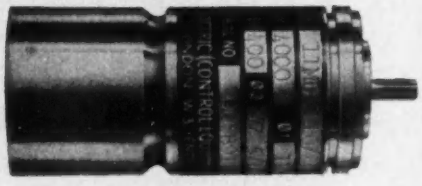

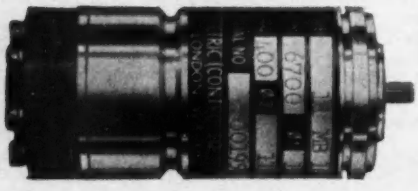

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size 11 components

SERVO MOTORS — High acceleration, good speed-torque linearity, split control phase for series or parallel connection, all motors are available with potted stators and stainless steel bearings. Wound for 20 to 180 volts 2-phase 400 c/s or 6 to 35 volts 2-phase 50 c/s, stall torque 40 gm. cm. minimum.

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- **Offering utmost reliability**
- **In some cases extremely compact**

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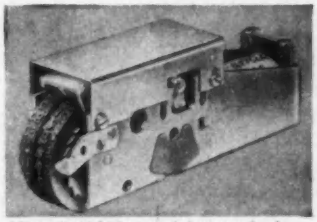

ZDmh—An 0-24 hours printout counter for vertical mounting.

PZ5e1R—5-digit counter with electrical and mechanical reset.

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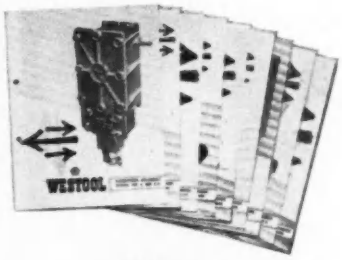

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(POLAR AND NON-POLAR)

Designed to withstand conditions of high temperature and high vibration.
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Voltage Range: 6 to 100V. d.c.
Capacitance Range: 0.2 to 200 μF.

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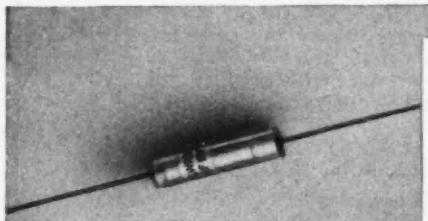
Type approved to R.C.S. 134B
Temperature Range: -40 to +85°C.
Voltage Range: 6 to 150V. d.c.
Capacitance Range: 0.15 to 200 μF.

TANTALUM electrolytic



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A foil type tantalum capacitor in its most economical form.
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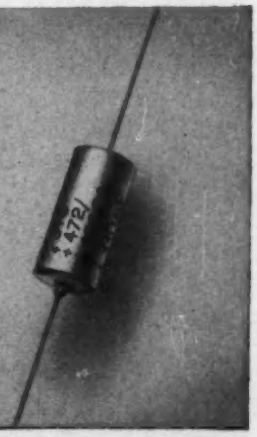
Voltage Range: 6 to 35V. d.c.
Capacitance Range: 1 to 220 μF.



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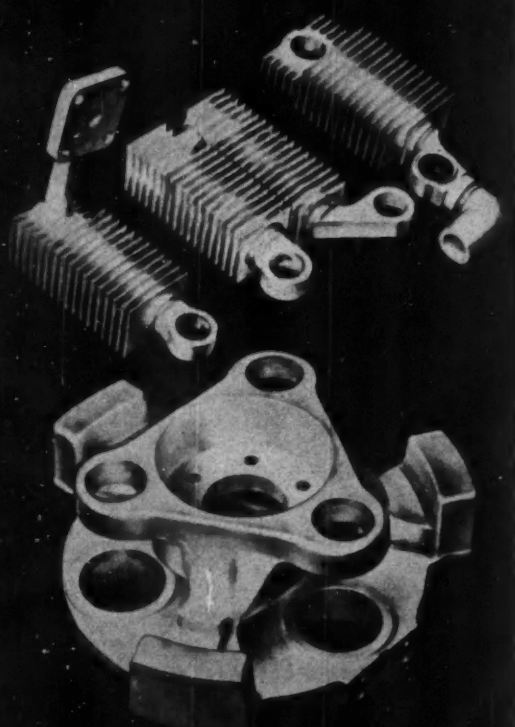
MARSTON aluminium flux-dip brazing



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Is it accurate?

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How many joints can you braze at a time?

Thousands

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Up to 9 ft. x 2 ft. x 2 ft.

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ICI

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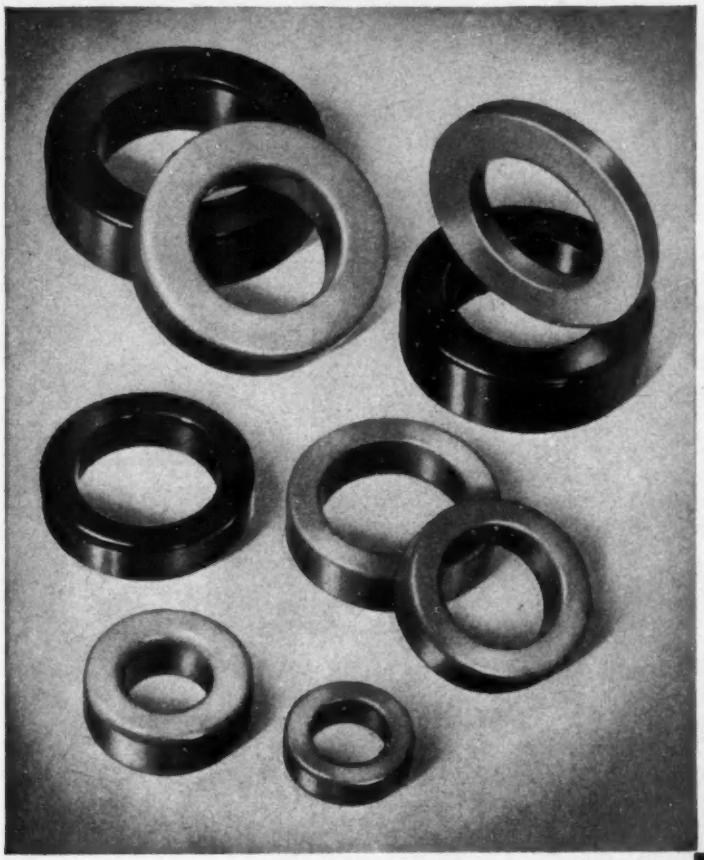
MAR295



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High 'Q' factors for frequencies up to 200 Kc s
Low core losses
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a calculation of mathematicians

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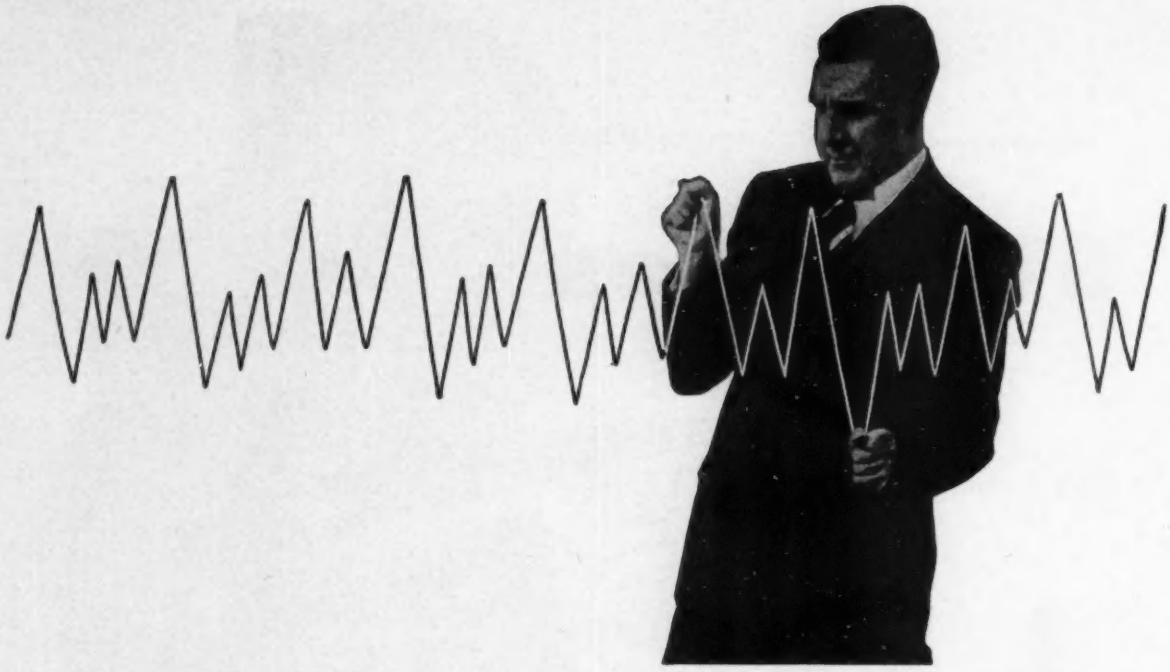

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IT/GD84

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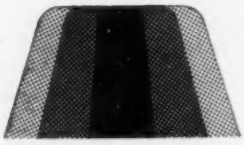
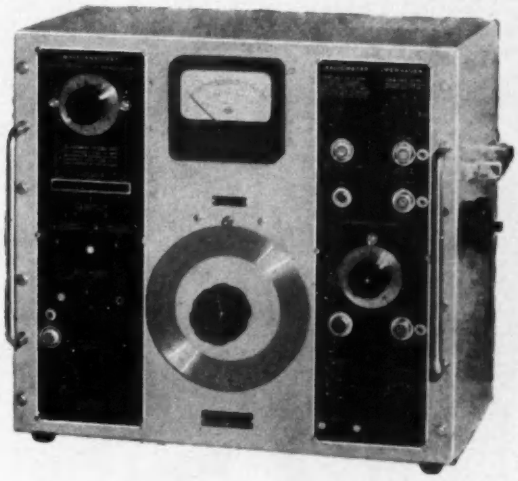
Wave Analyser

Type FRA2T

3 BANDWIDTHS



2 – 25 – 125 c/s (—1 db) provide for easy tuning over the entire frequency range and permit measurements to be made on frequency-modulated signals or in the presence of wow.



Built-in Tone Generator (B.F.O.) for selective measurements with provision for external level control. The B.F.O. can be offset from the Analyser tuning frequency by 0 to 16 kc/s for intermodulation measurements.

Frequency Response Recorder: The Analyser can be connected and mechanically coupled to the Recorder, Type NS3, which uses paper charts 20 cms long graduated directly in frequency and amplitude. Complete frequency response recordings can be made in 130 secs.

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Sharp Cut-Off on all Bandwidths. Response more than 60 db down at ±40 c/s in "2 c/s" position.

15 Ranges from 100 Microvolts to 1000 Volts f.s.d. Hum and noise less than 2 microvolts, lowest detectable signal 3 microvolts. Input impedance 2 megohms on all ranges.

This Wave Analyser is also available without Tone Generator, the type number is then FRA2.

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Contact pitch	*Board thickness*	*Number of ways*
0.100	0.062	8, 16, 24 & 32
0.150	0.062	8, 16, 24, 32 & 40
0.156	0.062	6, 10, 12, 15, 18, 22 & 27
0.200	0.062	4, 8, 12 & 16 (0.100 with alternate contact omitted)
0.200	0.062	8, 19, 24 & 32
0.200	0.093	24 & 28

DOUBLE-SIDED BOARDS

Contact pitch	*Board thickness*	*Number of ways*
0.150	0.062	16, 32, 48, 64 & 80
0.200	0.062	16, 32, 48 & 64
0.200	0.093	48 & 56

Many other types are available

SPECIAL DESIGN

0.150	0.062	10 & 32 single-sided & 20 double-sided
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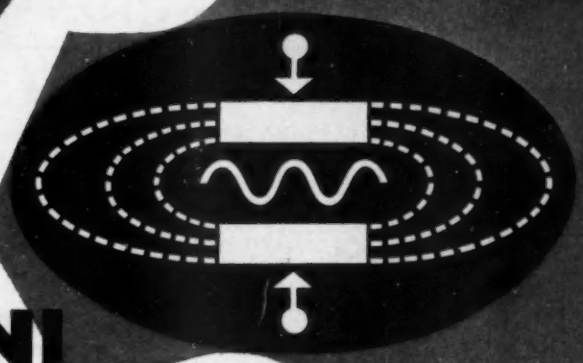

MARCONI SPECIALIZED COMPONENTS

and this is the story behind it

★ Every day, at one or other of Marconi's research establishments, new equipment is planned; new techniques are developed; new materials and new circuits are tested, and new problems are solved.

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Using advanced design technique the Chapman 1Kw Amplifier is unconditionally stable and will deliver a power output of 1Kw continuous sine wave.
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1 Kw Audio Frequency Amplifier as illustrated

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Frequency Range: 40-12,000 c.p.s.
Output Voltage: 25, 50 or 100v.
Output Impedance: 0.625 ohms, 2.5 ohms. or 10 ohms
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Sensitivity: 100 m/v into 600 ohms for 1 Kw output
Mains Supply: 200/250v at 50/60 c.p.s.
Dimensions: A fully enclosed 5 ft. high metal cabinet with hinged side and rear doors measuring 24½" × 20" deep
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Valves Used: ECC83, 2×EL84, 4×EL34, 2×TY3-250, 2×GZ34, 4×RRS-250

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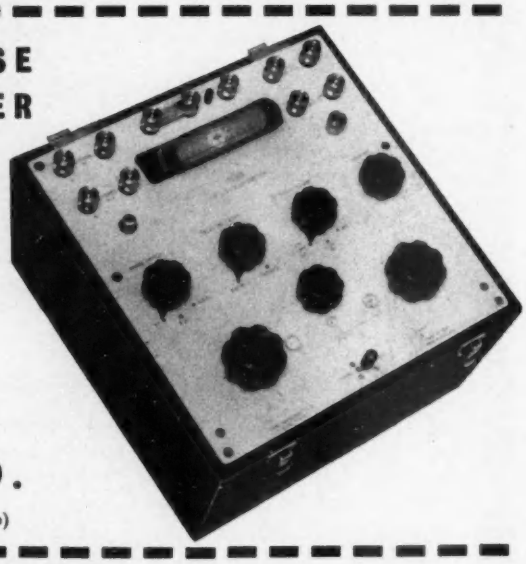

Three ranges are provided of 1 microvolt to 18 millivolts, 10 microvolts to 180 millivolts, and 100 microvolts to 1.8 volts. Accuracy—0.01% of maximum reading of range in use. In the latest model provision is made for controlling the supply circuits independently, and the switchgear and general arrangement have been modified to give improved stability and longer life.

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coil winding and potting

and manufacturers of electronic components to specification

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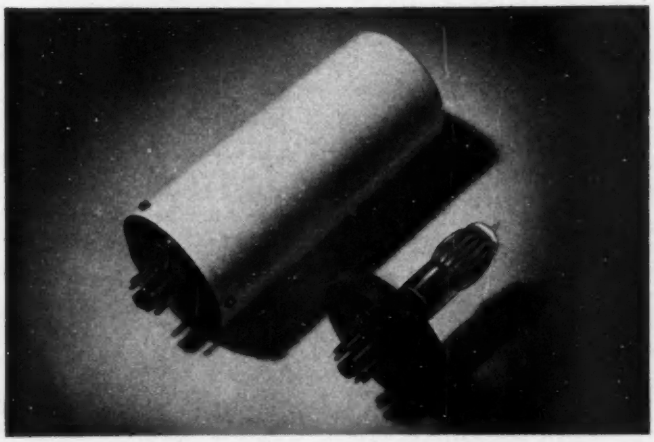
Da1260 EE

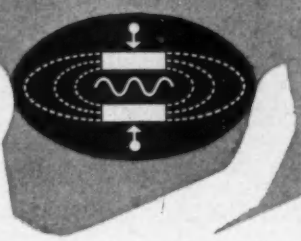
Quartz Crystal Ovens

STABLE TEMPERATURE ENSURING MAXIMUM FREQUENCY STABILITY

Switching differential 0·0014°C.
No thermostat
No thermometer switch

Orthodox crystal ovens, using thermostats or thermometer switches, are available for applications where wider temperature variations are acceptable.





This symbol has been adopted by the Marconi Specialized Components Group. The Marconi Company undertakes the design and manufacture of specialized components only when no suitable alternative is available; and in almost every case, Marconi specialized components are designed to more exacting standards and built to closer tolerances than any similar components. A preliminary catalogue is available, listing ferrite isolators and circulators, coaxial connectors, attenuators, terminations and switches; waveguide filters terminations, and bends; crystal filters and ovens.

MARCONI

SPECIALIZED RADIO COMPONENTS

Write for details of crystal ovens and other specialized components in the Marconi range, and address your enquiries to:

SPECIALIZED COMPONENTS GROUP
MARCONI'S WIRELESS TELEGRAPH COMPANY LTD.,
CHELMSFORD, ESSEX, ENGLAND

EE 32 034 *for further details*

Hewlett-Packard

DC and AC Voltmeters DC-1000 MC

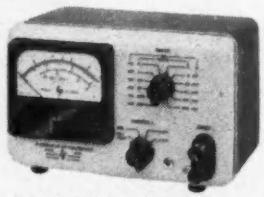
Precision accuracy, simple operation and sturdy dependability characterize these world-renowned -hp- voltmeters. Collectively, they offer you instrumentation for DC voltage measurements, or AC measurements to 1000 MC. As shown in the table, these instruments include wide range or precision models, a logarithmic scale instrument, a DC digital voltmeter, a transistorized instrument, a widely-useful microvolt-ammeter, the world's first **precision** commercial volt-ohm-ammeter, and a revolutionary new DC milliammeter that measures without direct connection to the circuit under test.

Many world-famous Hewlett-Packard laboratory instruments are now made in the new Hewlett-Packard GmbH plant at Böblingen, near Stuttgart. Here quality engineering and latest manufacturing techniques bring you instruments of exceptional performance at moderate price.

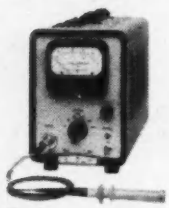
Instrument	Primary Uses	Frequency Range	Voltage or Current Range	Input Impedance	Price
-hp- 400 D	Wide range AC measurements High sensitivity	10 cps to 4 MC	0.001 to 300 V 12 ranges	10 megohms 15 $\mu\mu$f shunt	£ 89
-hp- 400 H	High accuracy wide range AC measurements	10 cps to 4 MC	0.001 to 300 V 12 ranges	10 megohms 15 $\mu\mu$f shunt	£ 128
-hp- 400 L	Log voltages, linear db measurements	10 cps to 4 MC	0.001 to 300 V 12 ranges	10 megohms 15 $\mu\mu$f shunt	£ 128
-hp- 403 A	Battery-operated portable; fast, accurate, hum-free AC measurements	1 cps to 1 MC	0.001 to 300 V 12 ranges	2 megohms 40, 20 $\mu\mu$f shunt	£ 103
-hp- 405 AR	Digital, automatic voltage measurement. Recorder output, automatic polarity	DC	0.001 V to 1,000 V (accuracy ± 0.2 % of reading ± 1 count)	11 megohms to DC	£ 339
-hp- 410 B	Audio, RF, VHF measurements; DC voltages; resistances	DC; AC - 20 cps to 700 MC	1.0 to 300 V 7 ranges	DC - 122 megohms; AC - 10 megohms / 1.5 $\mu\mu$f	£ 97
-hp- 411 A	Low level measurements at radio frequencies	5 KC to 1000 MC (Usable indications to 4000 MC)	10 mV to 10 V full scale in 7 ranges	Depends on probe tip used	£ 185
-hp- 412 A	Precision voltage, current resistance measurements	DC	1 mV to 1,000 V 1 μA to 1 amp	10 to 200 megohms, depending on range	£ 148
-hp- 425 A	Read μV, $\mu\mu$A; 100 db amplifier; medical, biological, physical, chemical	DC voltages as 100 db amplifier	10 μV to 1 V 11 ranges	1 megohm ± 3 %	£ 197
-hp- 428 A	Clip-on milliammeter eliminates direct connection, circuit loading	DC	0.3 mA to 1 amp, 6 steps, ± 3 % accuracy	-	£ 195
-hp- 456 A	Current measurements on meters, scopes	60 cps to 4 MC	1 mA to 1 amp rms		£ 78

Three of 11 -hp- Voltmeters

Model 411 A RF Millivoltmeter measures from 5 KC to 1000 MC (usable indications to 4000 MC) with 10 mV full scale deflection on most sensitive range.



Model 403 A AC Voltmeter transistorized, battery-operated portable weighs 5 lbs., covers 1 cps to 1 MC. Noise less than 30 μV.



Model 428 A
Clip-On DC Milliammeter
New probe clamps **around** wire under test, readily measures DC current even in presence of strong AC.

Prices delivered U.K. exclusive of duty where payable. Continuous progress in design may affect the above specifications which are therefore subject to change without notice.

For information, technical sales and engineering help, or a demonstration please write or call

Hewlett-Packard S.A.

Geneva (Switzerland) Rue du Vieux-Billard 1, Tel. (022) 26 43 36

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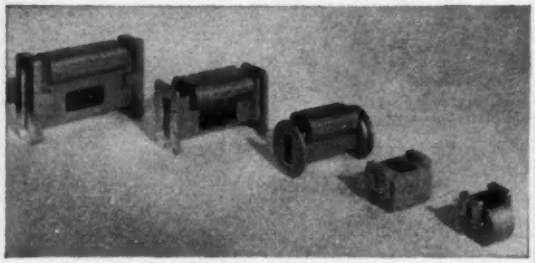
leads the way

Ferrite Isolators

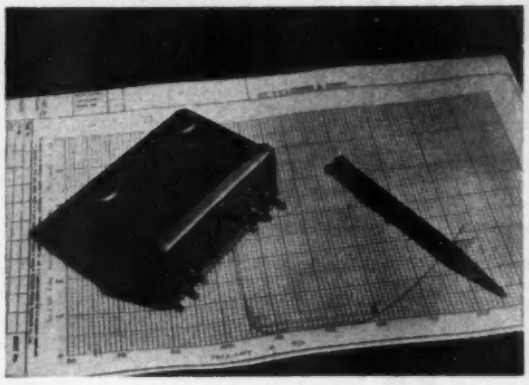


Existing Marconi designs cover most of the frequencies from 1.8 Kmc/s to 10 Kmc/s, and enable the following performance characteristics to be obtained:
Reverse losses of 45 dB or greater VSWRs 1.03.
Forward losses of 0.5 dB or less.
A wide range of ferrite devices, including circulators, is available; if your requirements fall outside our existing range we shall be pleased to consider a design to suit you.

50 ohm Coaxial Connectors

Designed to combine low VSWR with positive mechanical connection at 5000 mc/s, this connector is unique in its use for laboratory measurements and for any application calling for a stable and reliable match. Alternative arrangements are available for flexible cables or panel mounting use. The connectors are normally female but can be converted to male by the simple addition of a locating ring and connecting pin. The design incorporates a sealing ring for waterproofing the connecting joint.

Miniature Crystal Filters



Crystal filters operating at 100 kc/s with bandpass characteristics.
Pairs of upper and lower sideband selection filters for SSB applications.
IF filters at 455 kc/s.
Marconi's are constantly engaged in the development of new crystal filter techniques, and it is impossible to specify the large number of filter designs available. The Company's unique experience in this field enables us to offer advice and technical assistance with filter problems of any kind.

MARCONI

SPECIALIZED RADIO COMPONENTS

Write for details of crystal filters and other specialized components to:

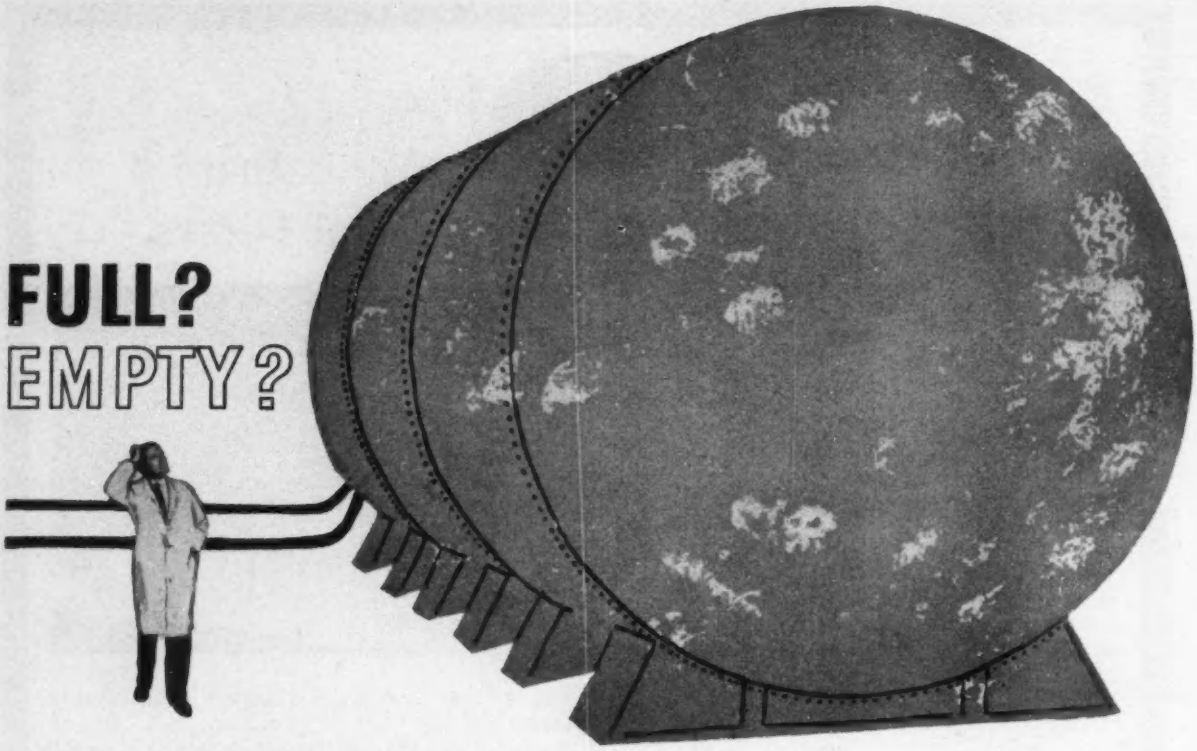
SPECIALIZED COMPONENTS GROUP

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

A preliminary catalogue is available listing specialized components for immediate delivery.

W2

FULL?
EMPTY?

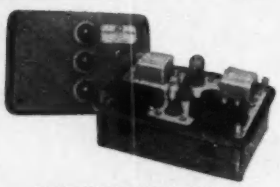


Here's one problem you don't have to bother with. There's a 100% reliable way of controlling the level of a conducting liquid in any type of pressurized or non-pressurized tank, wherever situated, regardless of size or height. It's all done automatically, without fuss, by the Firth Cleveland Conductivity Level Control System. Control is accurate to $\pm \frac{1}{16}$". Alternatively, the System provides high/low indication and alarm with the same accuracy. Here, are some of the main technical features:

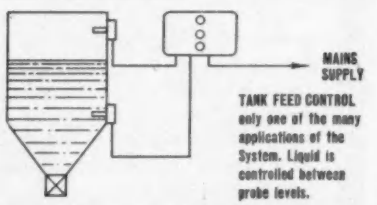
- Provides control of levels to $\pm \frac{1}{16}$" up to 1,000 ft. from site.
- Suitable for ALL conducting liquids.
- Completely reliable, 'fail-safe' fully transistorised printed circuitry.
- Operates at tank pressures up to 500 p.s.i.
- Probe units can be adapted for top of tank fitting.
- First-class after-sales service backed by a country-wide network of service engineers.

We shall be pleased to send you full details.

PROBE UNIT



AMPLIFIER AND LAMP ANNUNCIATOR



TANK FEED CONTROL only one of the many applications of the System. Liquid is controlled between probe levels.

FCI CONDUCTIVITY PROBE LEVEL CONTROL SYSTEMS

Firth Cleveland Instruments Ltd., 7 Cleveland Row, London, S.W.1. Telephone: WHitehall 3100 A MEMBER OF THE FIRTH CLEVELAND GROUP FC

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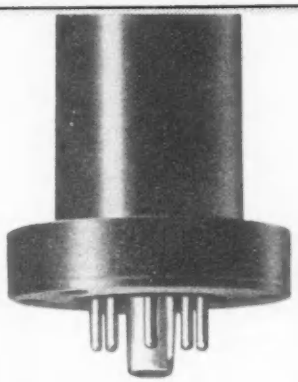
E.I.L ANNOUNCE NEW VIBRON DEVELOPMENTS

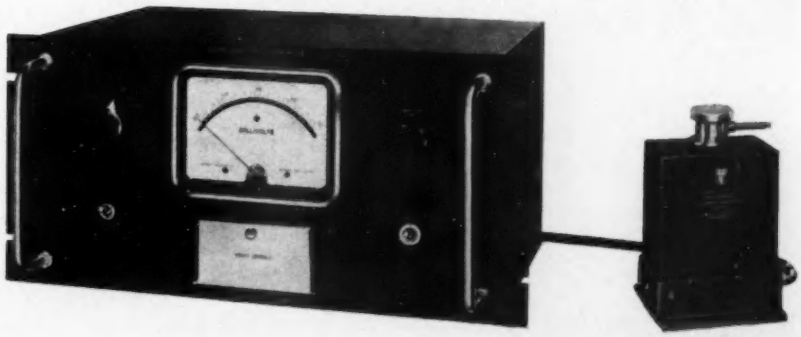


WITH TWO NEW ELECTROMETERS

Two highly versatile instruments which have extended the boundaries of experimental technique in several fields, share at least one feature: both owe their rock-steady zero stability and high input insulation to the E.I.L. VIBRON, a dynamic capacitor of exceptional precision.

The VIBRON MASS SPECTROMETER AMPLIFIER measures the very small beam currents encountered in modern mass spectrometry and discriminates down to 10^{-16} A against a random noise of 5×10^{-17} A r.m.s. With any selected value of shunt resistor, the gain is adjustable from 1 to 11 000; by this means the ratio of two mass species can be accurately determined. Its fast response enables the spectrum to be scanned rapidly.

The VIBRON LOGARITHMIC ELECTROMETER is scaled 0.1 to 1 000 millivolts and measures over these four decades without range switching. Using high value shunt resistors, currents down to 2×10^{-16} A can be detected.



ELECTRONIC INSTRUMENTS LIMITED

RICHMOND · SURREY · ENGLAND · RIChmond 5656

E52a

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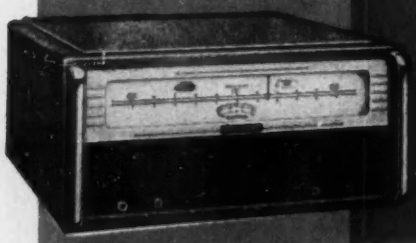
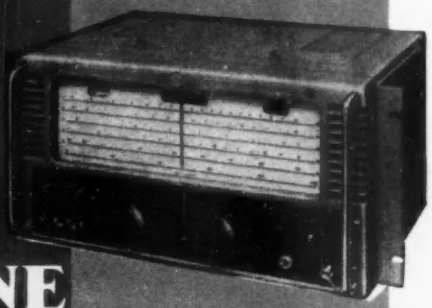
There's an

EDDYSTONE

COMMUNICATIONS RECEIVER *for* EVERY SERIOUS PURPOSE



Model "888" High Stability HF receiver. Superb specification and performance — designed to meet professional requirements. Range 320 kc/s to 30 Mc/s. Dial setting accuracy within 1 kc/s. Combines the advantages of crystal control with continuous tuning.

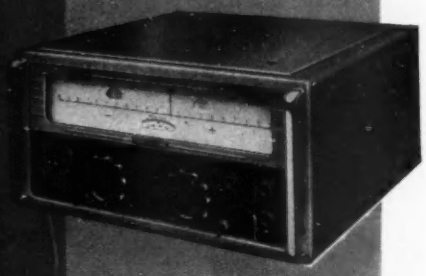


Model "730/4" General Purpose HF receiver. Developed to meet a Government specification and capable of an excellent performance. Range 480 kc/s to 30 Mc/s. (Special versions available giving crystal control and low frequency coverage.)

Model "680 2" General Purpose LF/MF receiver. Range 10 kc/s to 600 kc/s approximately. Full communications facilities.

Model "770U" Ultra High Frequency receiver, covering from 150 Mc/s to 500 Mc/s. Excellent performance throughout and suitable for receiving either FM or AM signals.

Model "770R" Very High Frequency receiver, covering from 19 Mc/s to 165 Mc/s in six ranges. Accepts AM, FM and CW. High sensitivity, fine control, thoroughly reliable.



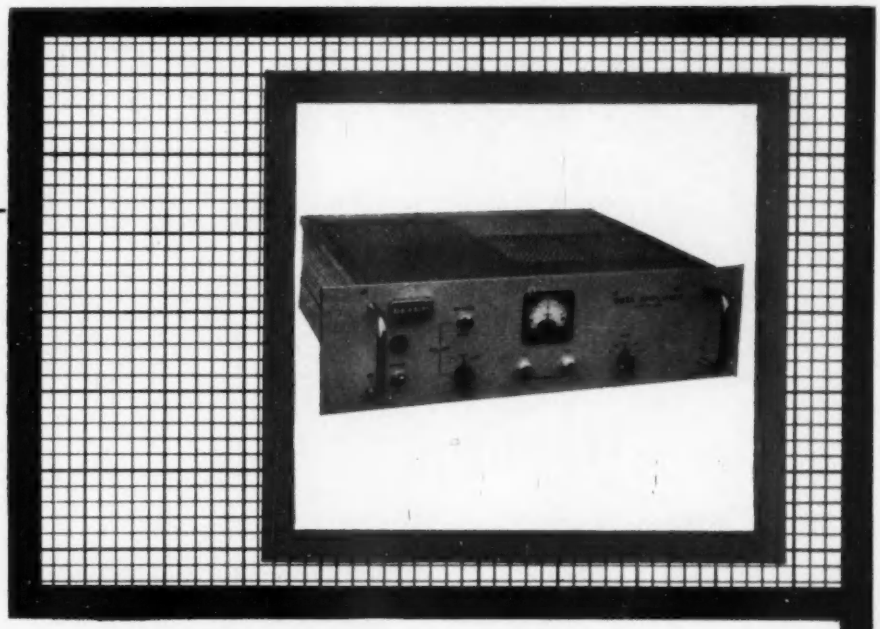
Model "770S" Extra High Frequency receiver, having a range from 500 Mc/s to 1000 Mc/s. Specially developed circuitry gives high performance.

RADIO PRODUCTS EDDYSTONE TRADE MARK

Please write for full Technical Specifications to the Manufacturers

STRATTON & CO. LTD., BIRMINGHAM, 31

Wholly new-



completely transistorised

DATA AMPLIFIER B.I.E.362

Unequalled performance is a factual claim for the new B. E. Transistorised Data Amplifier. It has been expressly designed and developed to meet the insistent demand for precise amplification of microvolt signals from transducers of all kinds.

High input impedance ensures that the unit will not load the signal source. Low drift and noise ensure minimum dependence upon power supplies and enable the unit to operate with a gain of up to 1,000 : 1.

High inphase rejection ratio, coupled with a completely floating input, guarantees minimum interference from common mode pick-up on the input lines.

Gain		Adjustable from 10 to 1,000 in steps
Linearity		0·1%
Drift		Less than 3μV r.m.s.
Noise	Rise Time	100 microseconds 10μV r.m.s.
	Rise Time	10 milliseconds 2μV r.m.s.
Band Width	Low Frequency	D.C.
	High Frequency	3 Db. down at 10 Kc/s.
Input Impedance		3 megohms
Input		Balanced floating 10μV to 1 V.
Inphase Rejection Ratio		D.C. 10^6 : 1.
		50 c.p.s. 10^5 : 1.
Output		10 volts, 5 mA.
Power Supplies		110/230 volts, 50 c.p.s.
Size		5¼" × 19" × 15¼"
Weight		20 lb.

Transistorised Data Amplifier

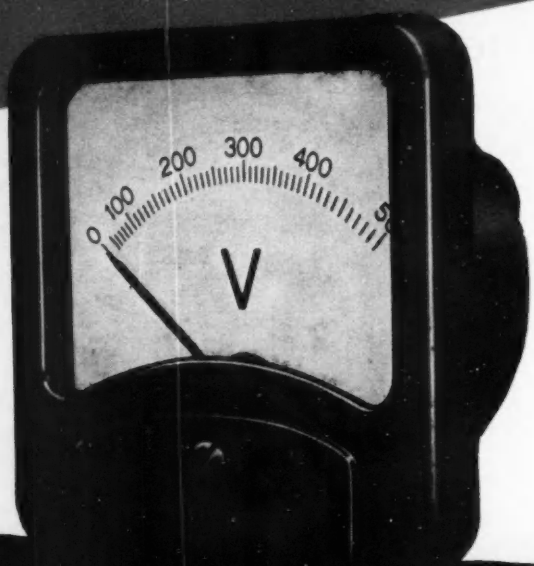
BLACKBURN ELECTRONICS LIMITED, BROUGH, YORKSHIRE

Telephone: Brough 121 *Member Company of the Hawker Siddeley Group*

EE 32 040 *for further details*

7 CASE TYPES

of flush mounting



MATCHING MINIATURE INSTRUMENTS

for switchboard designers

All 'ENGLISH ELECTRIC' miniature moving iron and moving coil instruments to B.S. 89-1954 can be supplied in the following nominal size cases: 2½ in. and 3½ in. Round Flush; 2 in., 2½ in. and 3½ in. Square Flush; 3 in. x 4 in. and 5 in. x 6 in. Rectangular Flush. Bold open scales give easy, accurate routine readings.

For utmost reliability all 'ENGLISH ELECTRIC' miniature instruments have been designed with a higher-than-normal torque/weight ratio in combination with lower power consumption and have been successfully subjected to:

RESISTANCE TO IMPACT SHOCK TEST of 200g in any plane

VIBRATION FATIGUE TEST—two million cycles at peak resonant frequency

OSCILLATORY TEST—up to one million operations

These non-breathing phenolic moulded cases can be fully sealed to protect the movements from acid-laden atmospheres and comply with specification B.S.2011.H3.

Publications on request to
The English Electric Company Limited,
Instrument Department,
Stafford

'ENGLISH ELECTRIC' *instruments*

THE ENGLISH ELECTRIC COMPANY LIMITED, ENGLISH ELECTRIC HOUSE, STRAND, LONDON, W.C.2.

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

INS.48

CLUTCH *in the palm of your hand!*

This versatile miniature magnetic instrument clutch is just one CROFTS contribution to the ever growing fields of light engineering and instrumentation. Versatile, because it can be used as clutch/coupling, clutch/brake or duplex clutch; and so miniature it sits right in the palm of your hand.

Inching, load locking, shaft positioning, high-speed motor reversal, speed synchronising—there's no end to its applications!

The standard range covers five sizes, transmitting torques from 4.2 to 420 oz. ins. at any normal speed. A range of positive-engagement clutches operating at similar speeds is available to transmit torques from 14 to 1400 oz. ins.

For full operating data, technical information and physical details of CROFTS instrument clutches—send for Publication 6013A.

Crofts
REG. TRADE MARK

CROFTS (ENGINEERS) LIMITED

POWER TRANSMISSION ENGINEERS

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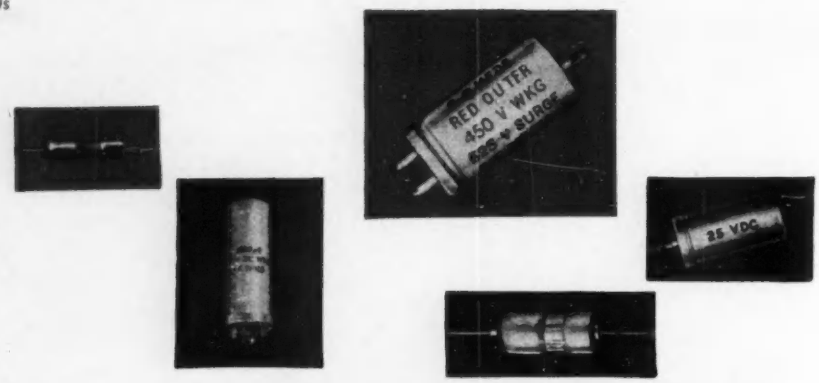
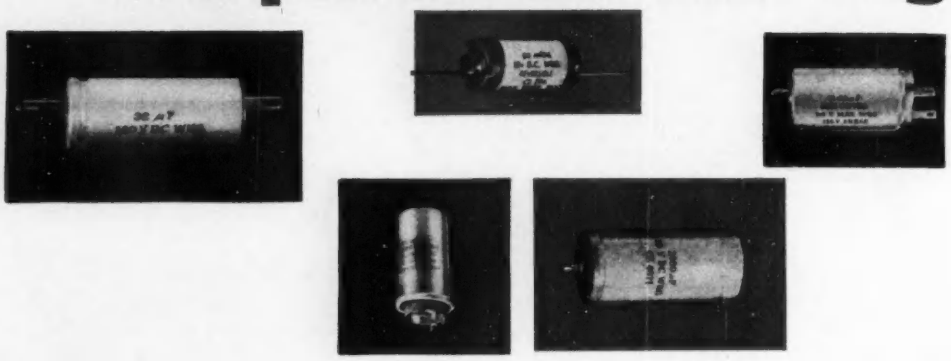


Capacitorability



In the design and production of thoroughly reliable electrolytic capacitors, Plessey have for years held a commanding lead. To every new demand made by rapid developments in radio, television and electronic equipment Plessey can respond by bringing to bear unrivalled experience, tremendous resources and highly skilled staff. Such is the care taken to obtain impeccable standards of quality and performance, that virtually clinical conditions of manufacture are maintained in the superbly equipped laboratories and workshops. These same exacting standards are imposed throughout the comprehensive range of capacitors produced by Plessey.

Whatever the requirement Plessey **provides the finest component**

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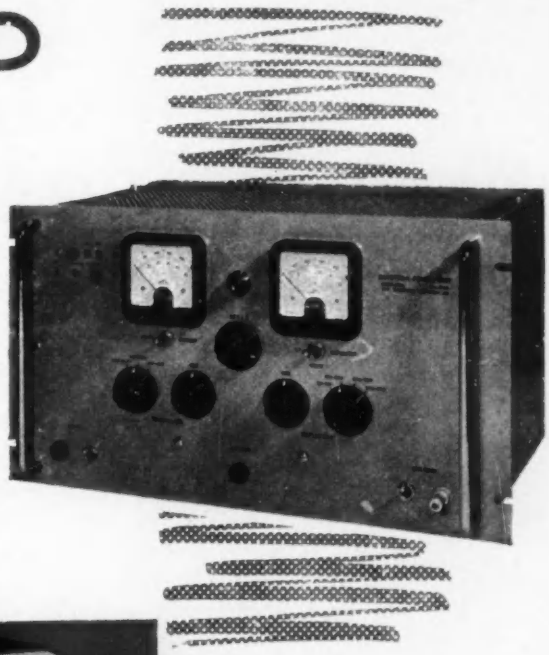
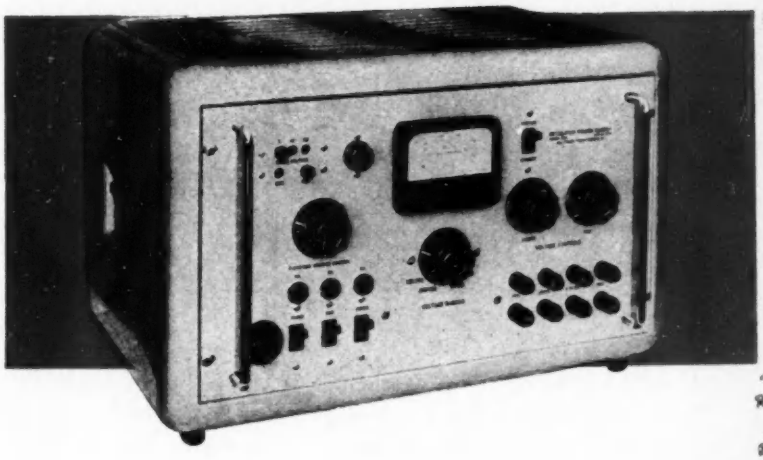
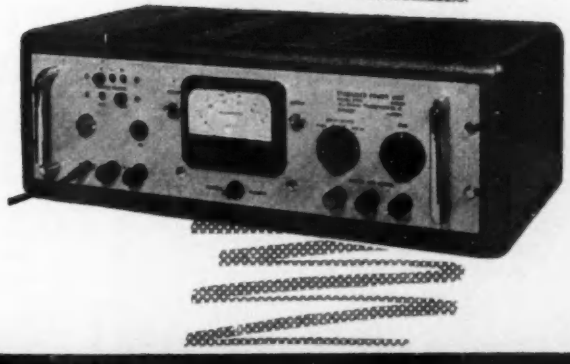
STABILISED POWER SUPPLIES



MODEL 2763
LOW VOLTAGE KLYSTRON SUPPLY
Resonator Supply 250 V — 400 V. 0-50 mA.
Reflector Supply 50 V — 400 V. 0-50 microamps.
L.T. Supply 5.5 V — 6.5 V. D.C. 0-1 Amp.
Aux. Supply for associated circuitry 400 V. 0-20 mA.
Stability better than 0.2% on H.T. lines for input variations ±10%.
Ripple less than 2 mV R.M.S.
PRICE £155 ex-works.



MODEL 508
0 — 500 V. D.C. 350 mA.
6.3 V. 10 Amps. A.C.
Neg. 250 V. 25 mA.
Stability of D.C. Outputs better than ±0.1% for input variations ±10%, and no load to full load current.
Ripple less than 3 mV R.M.S.
PRICE £98 ex-works.



MODEL 3798
0 — 50 V. D.C. 100 mA.
6.3 V. 5 Amps. A.C.
Maximum variation of D.C. Output Voltage less than 50 mV for input variations ±10%, and no load to full load current.
Ripple less than 1 mV R.M.S.
PRICE £60 ex-works.

A.P.T. ELECTRONIC INDUSTRIES LIMITED
CHERTSEY ROAD
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PHONE BYFLEET 4113/2/3/4
GRAMS APTRAN BYFLEET

PARMEKO ATLANTIC SERIES

STANDARD TRANSISTOR SUPPLY TRANSFORMERS

This range has been developed primarily for providing a power supply to transistorised circuits, but can also be used for many other applications where a low voltage output is required.

SECONDARY (a): Windings of 1 to 24V. are tapped in approximately 1 volt steps and those of 2 to 48V. in approximately 2 volt steps. The D.C. current ratings shown are those obtainable from a bridge rectifier with either choke or condenser filter.

SECONDARY (b): An H.T. winding is provided on certain models for stabilised circuits and this is tapped at each 50V. from 0-250 volts.

All Standard transformers have their primaries wound 10-0-200-220-240V., 50 c.p.s. supply. An electrostatic shield is fitted between primary and secondary windings on all models.

CATALOGUE No.	SECONDARY (A)			SECONDARY (B)	
	VOLTAGE R.M.S.	RATING (AMPS)		VOLTAGE R.M.S.	RATING
		R.M.S. OR D.C. CHOKE	D.C. COND.		R.M.S. CURRENT
P-2945	1 to 24V.	1·6A.	1·0A.	—	—
P-2946	2 to 48V.	1·6A.	1·0A.	—	—
P-2947	1 to 24V.	3·2A.	2·0A.	—	—
P-2948	1 to 24V.	1·6A.	1·0A.	0–250V. (50V. Steps)	40mA
P-2949	2 to 48V.	1·6A.	1·0A.	0–250V. (50V. Steps)	40mA
P-2950	1 to 24V.	3·2A.	2·0A.	0–250V. (50V. Steps)	40mA
P-2951	2 to 48V.	3·2A.	2·0A.	0–250V. (50V. Steps)	40mA
P-2952	1 to 24V.	5·0A.	3·2A.	0–250V. (50V. Steps)	40mA
P-2953	2 to 48V.	5·0A.	3·2A.	0–250V. (50V. Steps)	40mA

A table showing method of connection is supplied with each transformer.

- ★ *DESIGN: Complies with BSS 2214.*
- ★ *CONSTRUCTION: Steel encased, cold-paint filled.*
- ★ *DIMENSIONS: Plan and Fixing to RCL.215.*
- ★ *HUMIDITY: Category H2 or Better.*
- ★ *TERMINALS: Patented design insulators, layout to RCL.215.*
- ★ *MOUNTING: Upright or Inverted.*
- ★ *FINISH: Grey Hammertone, stoved enamel.*
- ★ *STANDARDS: Ranges of Transformers and Chokes available from stock.*

STANDARD SMOOTHING CHOKES

Catalogue Number	D.C. Current	Inductance	Approx. D.C. Resis. Ohms.	Model Size	Terminal Positions
P-2954	1·6A	40mH	0·62	9000/49	2–3
P-2955	1·6A	60mH	0·90	9000/57	9–10
P-2956	3·2A	15mH	0·31	9000/49	2–3
P-2957	3·2A	35mH	0·39	9000/65	9–10
P-2958	5·0A	9mH	0·15	9000/57	9–10
P-2959	5·0A	25mH	0·16	9000/73	9–10

The Atlantic Series can accommodate transformer designs rated up to 650VA at 50 c.p.s. We shall be pleased to quote for your specific requirements.

PARMEKO LTD · PERCY ROAD · LEICESTER · ENGLAND

C 13

EE 32 045 *for further details*

PERMANENT ATTRACTION

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cast permanent magnets

The outstanding qualities of MAGLOY materials enable the production of precision-cast magnets, even of small sizes, to relatively close tolerances. In addition, aluminium and synthetic jackets, for mounting purposes, provide a complete safeguard against magnetic damage.

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PM2

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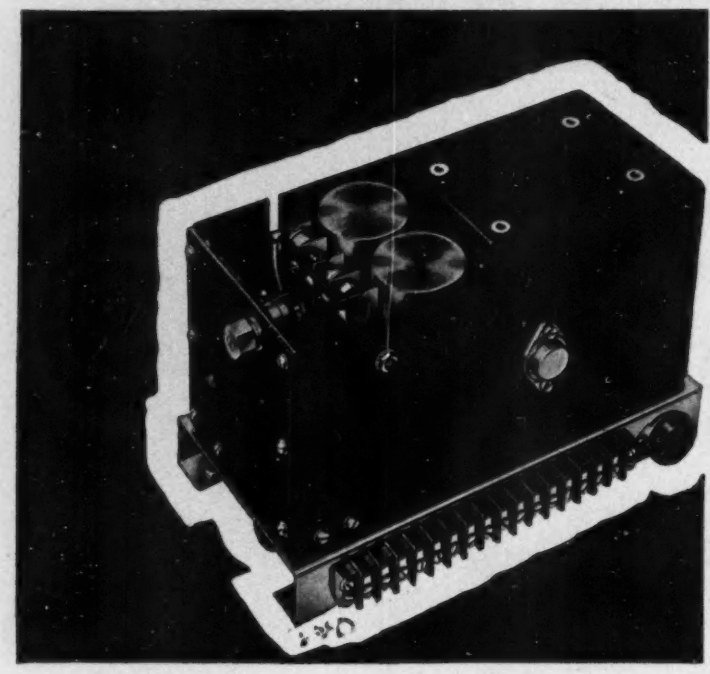
CHOOSE BELIX



CHOOSE BELIX TRANSISTOR POWER SUB-UNITS

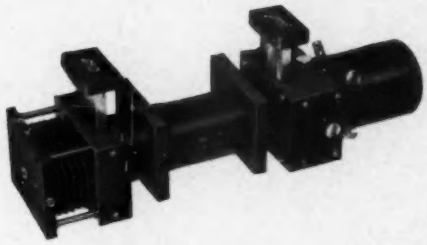
THE BELIX COMPANY LIMITED • VICTORIA ROAD SURBITON SURREY • ELM 9118

TYPE No.	TSS 61	TSS 62	TSS 63	TSS 300	TSS 04	TSS 14	TSS 24	TSS 34	TSS 44	TSS 241	TSS 114	TSS 104	TSS 94	TSS 84	TSS 74	TSS 121	TSS 122	TSS 123	TSS 124	TSS 125	TSS 51	TSS 52	TSS 53	TSS 54	TSS 55
OUTPUT d.c. volts:	0-12	0-12	0-12	0-24	0-6	6-14	12-20	16-24	20-30	0-24 *	0-6	6 14	12-20	16-24	22-30	0-6	6-12	12-20	16-24	20-30	0-6	6-12	12-20	16-24	20-30
OUTPUT amps (max.):	0·1	0·3	0·5	1·0	1·0	1·0	1·0	1·0	1·0	1·0	2·0	2·0	2·0	2·0	2·0	6·0	6·0	6·0	6·0	6·0	10·0	10·0	10·0	10·0	10·0
STABILITY RATIO (7% mains)	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1	1000 : 1
SOURCE RESISTANCE Ω less than:	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0 01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01
A.C. IMPEDANCE Ω (max.) to 200 kc/s:	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15	0·15
RIPPLE (pk-pk) mV less than:	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0	1·0

* Provides two independent outputs. ● Available as plug-in or wire-in sub-unit. TSS 61, 62, 63 are continuously variable; all other units have coarse step plus fine adjust facility.

belix

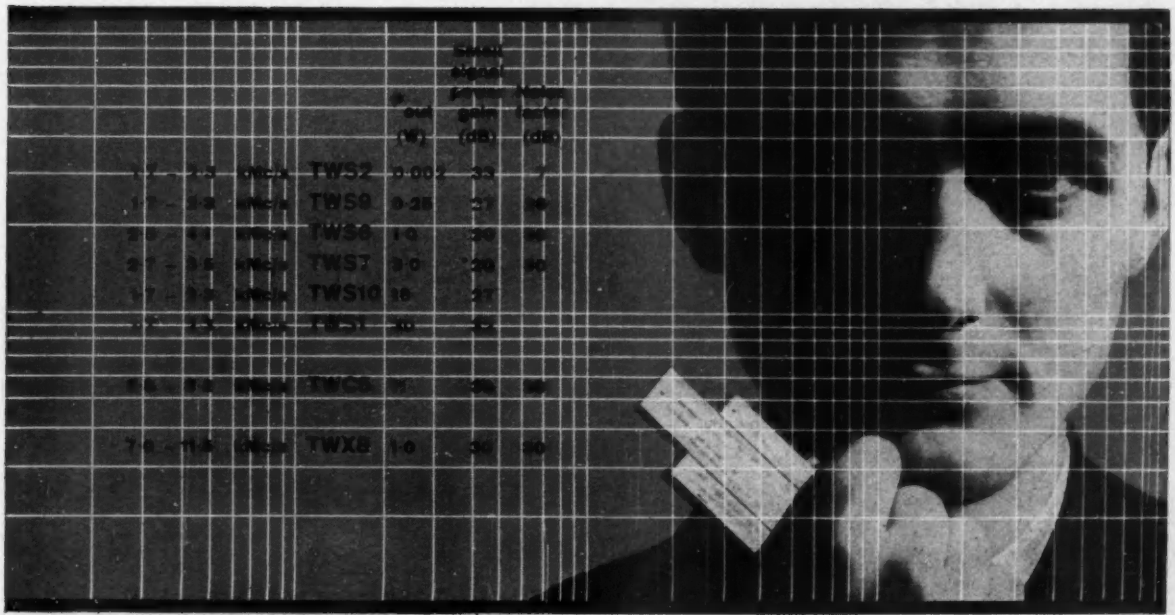
EE 32 047 *for further details*



WE CAN GET YOU ■ OUT OF A

travelling wave tube PROBLEM

One tube designed to solve many problems is the TWC5. It has an output of 11 watts and a gain of 39 dB. over a frequency range 5.8–8.2 kMc/s. It is readily replaceable in the periodic magnetic circuit. If you have a valve problem simply telephone RIV 3431 and ask for our Technical Information Centre or write to the address below.



G.E.C.

THE M-O VALVE CO LTD

BROOK GREEN HAMMERSMITH LONDON W6

the ULTIMATE in radio frequency connectors . . .

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✳ CO-AX cables
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✳ ULTRA LOW
CAPACITANCE & ATTENUATION

TYPE	pF/ft	IMPED	O.D.
C1	7.3	150	.36
C11	6.3	173	.36
C2	6.3	171	.44
C22	5.5	184	.44
C3	5.4	197	.64
C33	4.8	220	.64
C4	4.6	229	1.03
C44	4.1	252	1.03

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small motors, big loads

THE BRILLIANT RANGE OF SIEMENS & HALSKE GEARED MINIATURE D.C. MOTORS. Siemens & Halske high efficiency miniature D.C. motors are available in three sizes, the largest being approximately $1\frac{1}{4}$" x $\frac{3}{4}$" including gearbox. Motors are available with working voltages up to 4V D.C., but they will in fact turn from a signal as low as 50 mV. Torques are impressive—up to 270 cm.gms.—and an electro-mechanical efficiency of the order of 70%. The working temperature range is —35°C to +60°C.

B&R RELAYS LIMITED

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Telephone: Harlow 25231/4 *Member of the Gas Purification Group*

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TETRODES

FOR COMMUNICATIONS & INDUSTRY

The English Electric Valve Co. Ltd. offers a range of natural cooled tetrodes for the lower power communication and industrial application. The majority of the types in this range, comprising both single and double tetrodes, are capable of operation, at full ratings, well into the V.H.F. band — up to 250 Mc/s in the case of the C178A/5894. Even higher frequencies may be attained with suitable de-ratings. All are equivalents or near equivalents to American and CV types.

For full details of these valves please write to the address below.

'ENGLISH ELECTRIC'

	E.E.V. Type	American Type	British Services Type	Operating Frequency Mc/s	Max. Anode Dissipation (W)
FOR NEW EQUIPMENTS	4D32	4D32	CV3543	60	50
	C178A/5894	5894	CV2797	250	20+20
	C1108	4-125A*	CV2130	120	125
	C1112	4-250A*	CV2131	75	250
	C1134	6252 *	CV2799	150	10+10
MAINTENANCE	813	813	CV26	30	100
	829B	829B	CV2666	200	20+20
	832A	832A	CV788	200	7.5+7.5

* *Near equivalent*

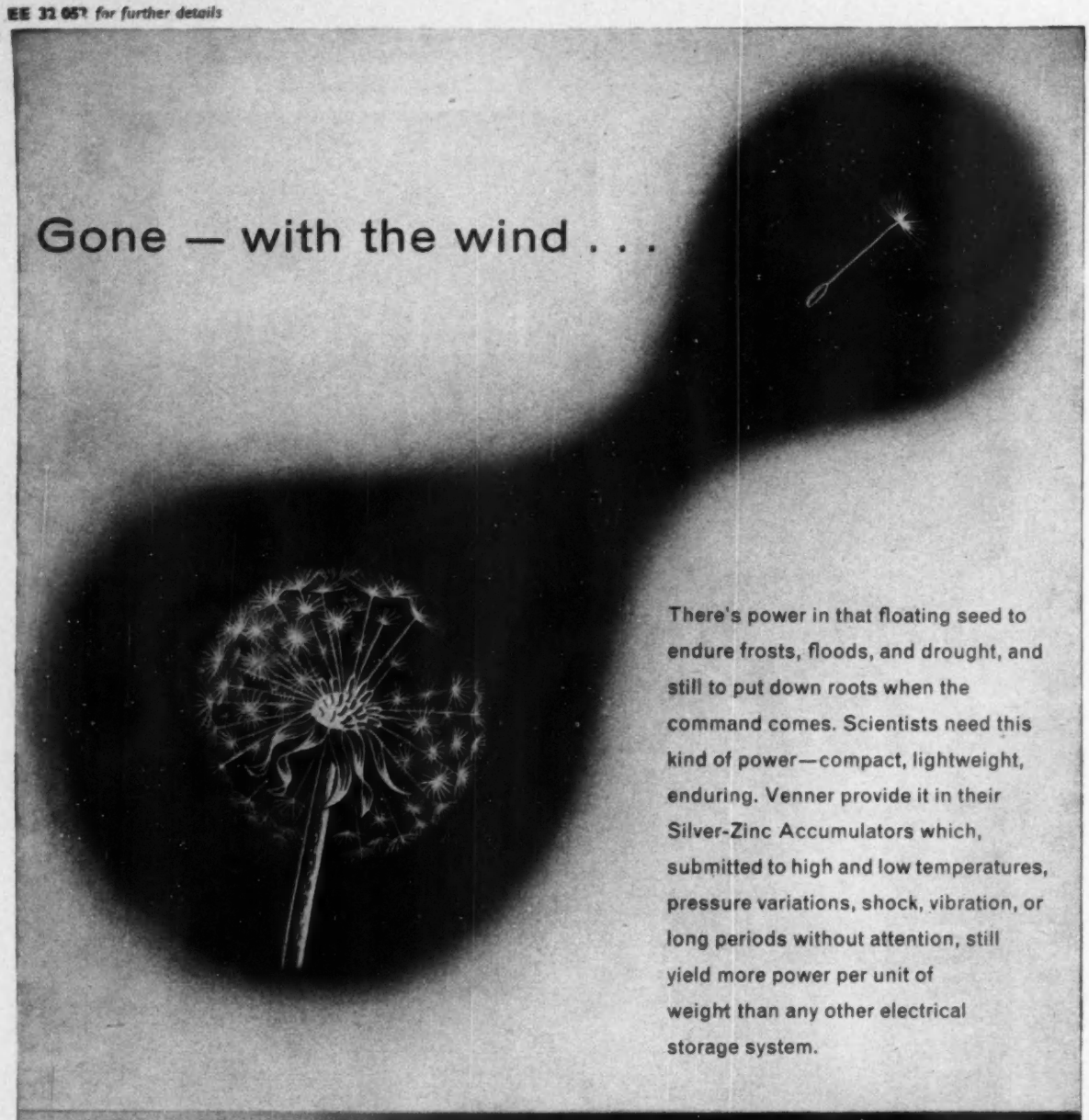
AGENTS THROUGHOUT THE WORLD

ENGLISH ELECTRIC VALVE COMPANY LIMITED

Chelmsford, England | *Telephone: Chelmsford 3491*

AP 169

EE 32 057 for further details



There's power in that floating seed to endure frosts, floods, and drought, and still to put down roots when the command comes. Scientists need this kind of power—compact, lightweight, enduring. Venner provide it in their Silver-Zinc Accumulators which, submitted to high and low temperatures, pressure variations, shock, vibration, or long periods without attention, still yield more power per unit of weight than any other electrical storage system.

VENNER SILVER-ZINC ACCUMULATORS

VENNER SILVER-ZINC ACCUMULATORS provide lightweight power for satellites, guided missiles, airborne equipment of all kinds, telemetering systems, etc.

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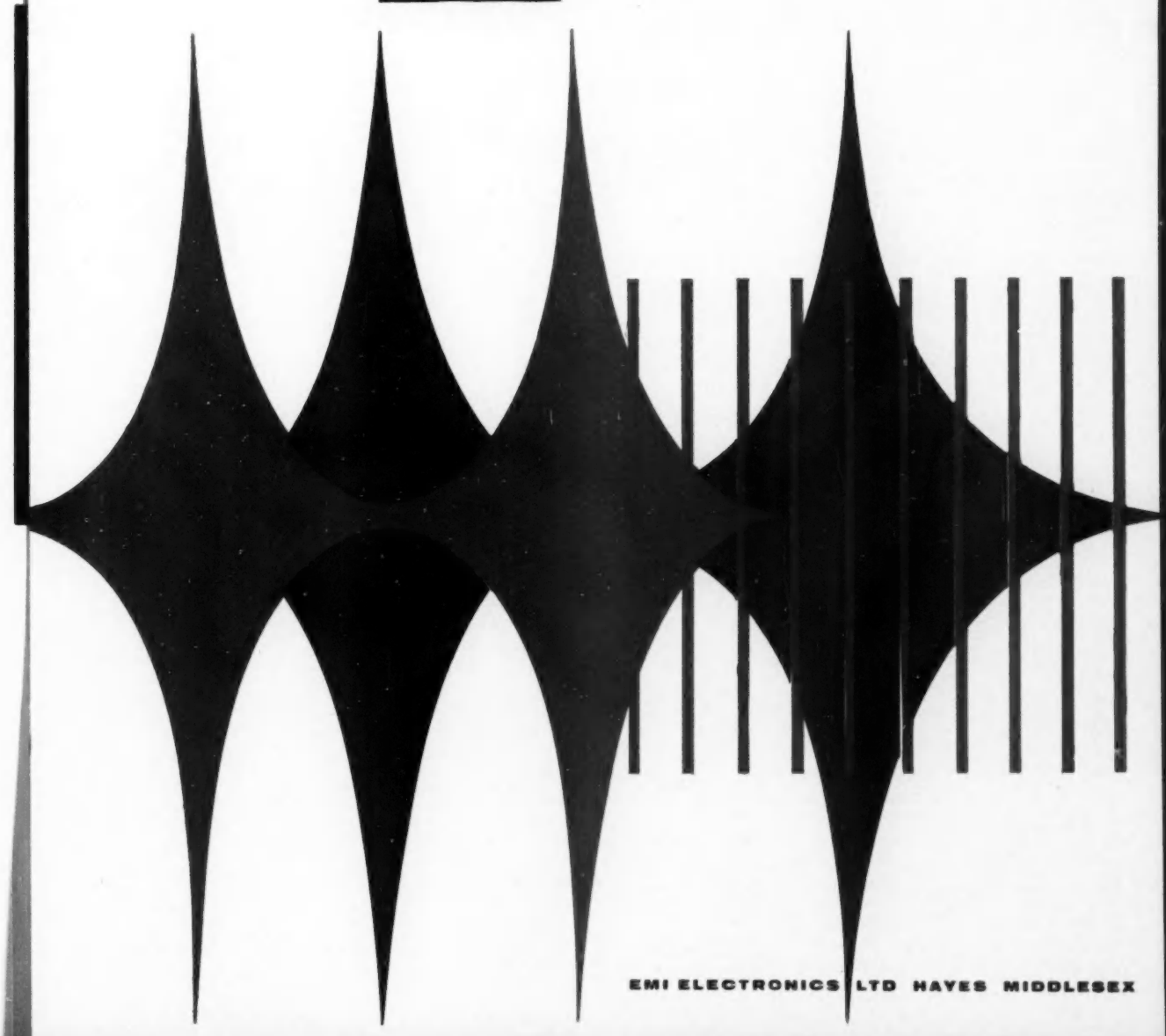
TEAR ALONG THIS PERFORATION

Overleaf the new Selection Charts for Klystrons and Photomutiplier Tubes.

Your new detachable short catalogue of

EMI

Precision Instruments



EMI ELECTRONICS LTD HAYES MIDDLESEX

NUCLEAR HEALTH INSTRUMENTS

PORTABLE CONTAMINATION MONITOR TYPE 1

TOP LEFT Simultaneously monitors Alpha and Beta/gamma contamination.
Transistors used for long life and dependability.
Audible and visual indication of contamination from 0-5000 counts/sec.

HAND AND CLOTHING MONITOR TYPE 1

LEFT Simultaneous monitoring for Alpha and Beta/gamma
Audible and visible warnings of count.
Background radiation compensation.
Independent probes for Alpha and Beta/gamma contaminatio

PROBES

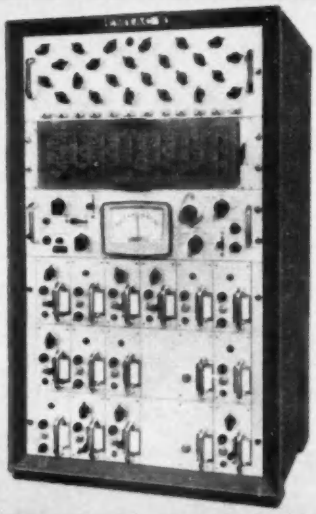
A range of probes is available:

1. AP2 50 cm^2 alpha probe, using a scintillation counter.
2. AP3 100 cm^2 alpha probe, using a scintillation counter.
3. BP2 Beta-Gamma probe, using a B12H geiger counter.
4. BP3 Beta-Gamma probe, using a B12H geiger counter.
5. DP2 50 cm^2 dual phosphor probe for Alpha and Beta/gamma monitoring.
6. GP2 Gamma probe, using Na I crystal and scintillation counter.
7. BP4 low energy Beta probe using a scintillation counter.

ANALOGUE COMPUTERS

EMIAC II

RIGHT A general purpose analogue computer of flexible design. One of the most advanced instruments of its kind, it enables the smallest user to order a "one-off" Computer at a mass production price, while the largest organisation can obtain a general purpose computer, or a special simulator of any desired size and characteristics.



ELECTRONIC PHOTOGRAPHIC EQUIPMENT

CONTACT PRINTER TYPE CP18S. ENLARGER TYPE EP10

Electronic control of dodging and exposure of photographic negatives.
More detail from both shadows and highlights.
Consistent repetitive prints.

CONTACT PRINTER, TYPE CP 18S

RIGHT Prints from cut negatives from 2¼ in. square to 14" x 18".

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E.M.I. ELECTRONICS LTD
INSTRUMENT DIVISION · HAYES · MIDDLESEX
TEL: SOUTHALL 2468, EXT. 2223

EMI

Klystron and waveguide data

SELECTION CHART

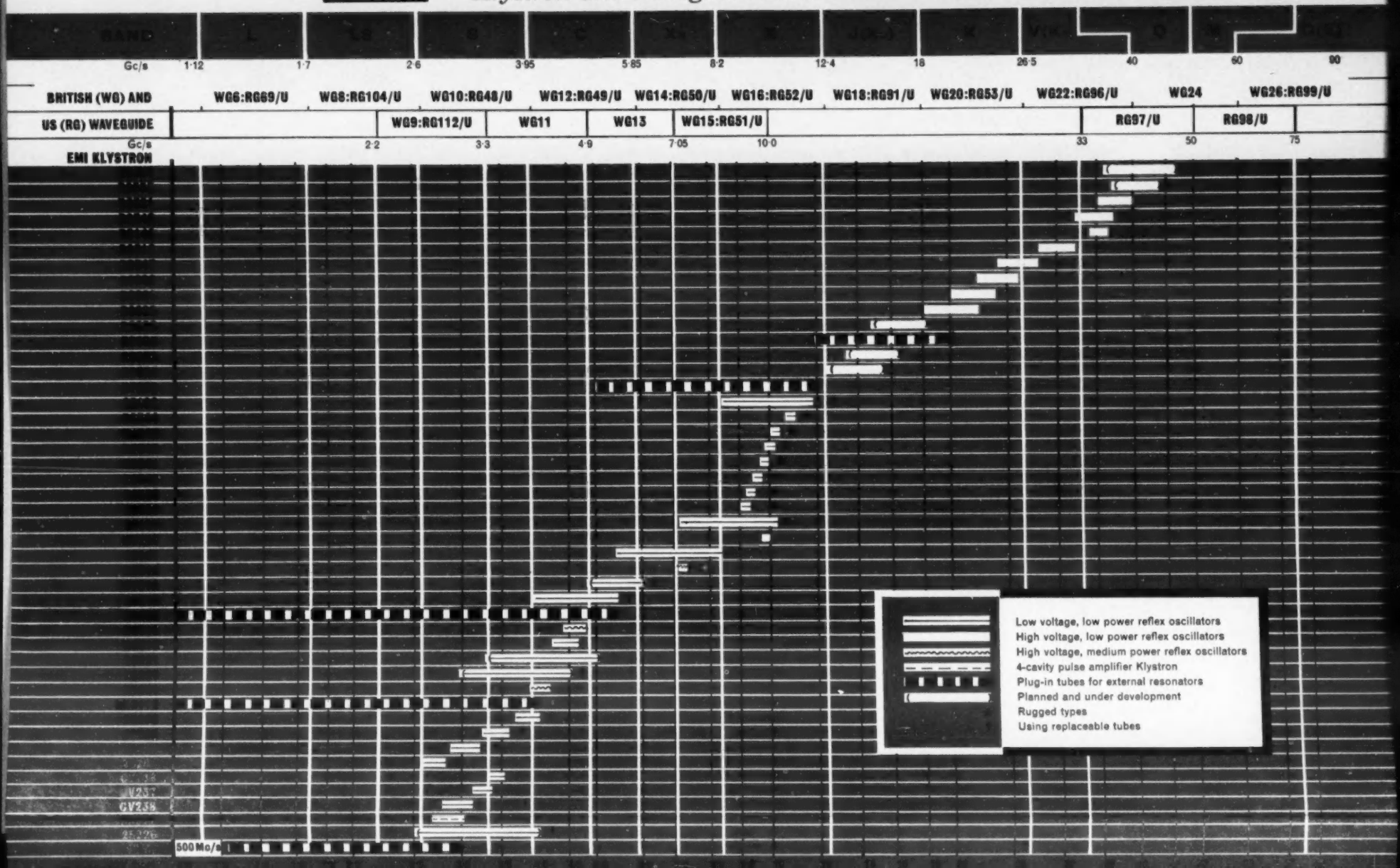
	L BAND	S	LS	B	C	XC	X	(KU)	K	KA	Q	M	(UG)
Gc/s	1·12	1·7	2·6	3·95	5·85	8·2	12·4	18	26·5	40	60	90	
BRITISH (WG) AND	WG6:RG69/U	WG8:RG104/U	WG10:RG48/U	WG12:RG49/U	WG14:RG50/U	WG16:RG52/U	WG18:RG91/U	WG20:RG53/U	WG22:RG96/U	WG24	WG26:RG99/U		
US (RG) WAVEGUIDE		WG9:RG112/U	WG11	WG13	WG15:RG51/U				RG97/U	RG98/U			
Gc/s		2·2	3·3	4·9	7·05	10·0			33	50	75		
EMI KLYSTRON													

Low voltage, low power reflex oscillators
High voltage, low power reflex oscillators
High voltage, medium power reflex oscillators
4-cavity pulse amplifier Klystron
Plug-in tubes for external resonators
Planned and under development
Rugged types
Using replaceable tubes

EMI

Klystron and waveguide data

SELECTION CHART



EMI

Photomultiplier tube selection chart

PHOTOCATHODE DATA

The range of spectral sensitivity is given with quantum efficiency (Electrons per photon) at points indicated. Tubes having given end-window cathode type are listed.

WAVELENGTH · Microns. 0 · 0·2 · 0·4 · 0·6 · 0·8 · 1·0 · 1·2

AgMgO surface in vacuo. 9603 Particle multiplier.

Developmental tubes with LiF windows.

Developmental tubes with Sapphire windows.

Au on fused Silica 6255G

Mg on fused Silica 6255Mg

SbCs on fused Silica
"S" Cathode on Silica. 6255S, 6256S, 9526S, 9552S

SbCsO on fused Silica
S13. 6255B, 6256B, 9526B, 9530Q, 9531Q, 9552B,

BiAgOCs on fused Silica
S10 on Silica. 9529B

SbNaKCs on fused Silica
Trialkali on Silica. 9558Q

AgOCs on fused Silica
Developmental S1 on Silica

BiAgOCs on U.V. glass
S10. Extended response. 9592B

SbCsO on U.V. glass
S11. Extended response. 9621B

SbNaK on glass 25μA/L
Bialkali. Cathode. 9607B. For operation up to 150°C.

SbCs on glass 40μA/L
"S" Cathode. 6097S, 9502S, 9514S, 9524S, 9536S

SbCsO on glass 70μA/L
S11. 6094B, 6097B, 9502B, 9514B, 9524B, 9530B, 9531B, 9536B, 9545B, 9578B, 9579B, 9583B, 9584B, 9593B, 9618B, (9623B

BiAgOCs on glass 30μA/L
S10. 6095B, 9554B

SbNaKCs on glass 150μA/L
S20. 9558B, 9578TA

AgOCs on glass 15μA/L
S1. 9553B

DYNODE CHARACTERISTICS

Tubes are made with dynode structures appropriate to their application.

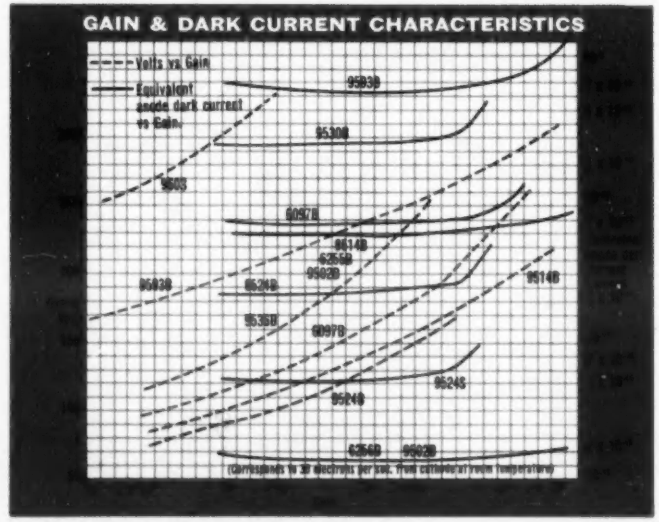
Box & Grid (Coated with SbCs). Give very high stage gain at low voltage and are used in small diameter tubes (e.g. 9524B) particularly for portable apparatus. Time characteristics are relatively poor, and peak anode currents are limited to about 50mA.*

Venetian Blind dynodes (SbCs Coated). Give good average gain and very low dark currents. The large diameter allows of good collection efficiency from the cathode. Rise times of 2" tubes are about 7 nanoseconds and peak currents up to 300 mA may be drawn.

Focused structures (AgMgOCs) give very good time characteristics, with rise times around 2½ nanosecs, but gain is relatively lower than the other types and dark current worse.

AgMgO dynodes (whether F or VB) made without Cs in the tube (e.g. 6255G, 9607) give low gains and require high voltage for operation. Dark Current in μA divided by overall sensitivity in Amps per Lumen gives equivalent Dark Current in Lumens and should be independent of gain. (*Note. Average anode currents are limited to 1mA max.)

GAIN & DARK CURRENT CHARACTERISTICS



Note: The dark current of a PM tube may be relatively high when the tube is first operated, but will quickly decrease during operation in the dark, and may go on decreasing for several days before reaching a limiting value.

For further details, please write or telephone: **E.M.I. ELECTRONICS LTD**

ENVELOPE DIAMETER

½" 13mm	1" 25mm	2" 50mm	3"	5" 130mm	7"	10"	12" 300mm
	11BG 9524 9526 9529 9592 9600* 9621 (B14B)	10VB 9536 9552 9553 9554 (B14A) 11VB 9584 (B14A) 6094** 6095 6097 (B15B) 9558 9607† (B19A) 13VB 6255 6256** 9502** 9514 (B15B) 14F 9593‡ (B19A)	10VB 9578 (B14A) 11VB 9531 (B15B)	10VB 9579 (B14A) 11VB 9583 (B14A) 9530 9618 (B15B)	11VB 9623 (B15B)		11VB 9545 (B15B)
Developmental							

NOTES † AgMgO coated dynodes.

‡ AgMgOCs coated dynodes.

All other tubes have SbCs coated dynodes.

** 10mm cathode.

* Side Wall Sensitive 20cm² total cathode area.

B14A is a Diheptal base, all other bases are of glass.
PTFE Sockets are available for the glass base tubes.
The operation of PM tubes may be affected by magnetic fields and μ-metal shields are available.
PM tubes should not be operated at excessive light levels with voltage applied.
Dark current is dependent on operating temperature. The data given refers to 20°C. A reduction in temperature to —10°C will give a decrease of ca. 10:1.

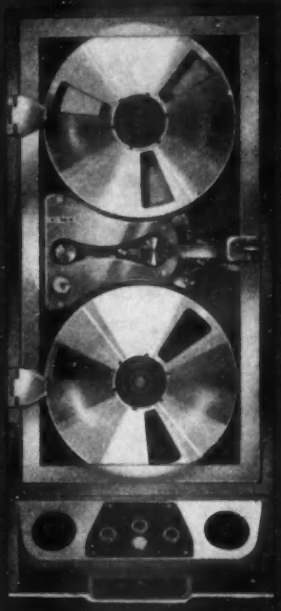
VALVE DIVISION · HAYES · MIDDX. Tel: SOUthall 2468 Ext 2168

details

TEAR ALONG THIS PERFORATION

INSTRUMENTATION TAPE DECKS

RIGHT Six tape speeds available.
Four multitrack magnetic heads (up to 24 tracks per 1" tape) can be employed.
Tape speed ratios up to 128 : 1.
Up to 14" diameter tape spools can be used.
Versions available for 1", $\frac{3}{4}$", $\frac{1}{2}$" and $\frac{1}{4}$" wide tape.
Tape speeds available cover the range $\frac{1}{4}$ in/sec-120 in/sec.
Fast bi-directional spooling.



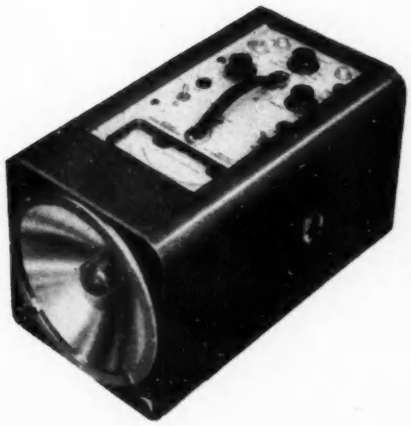
EMIDATA MULTITRACK HEADS

RIGHT CENTRE Interleaving pairs provide up to 24 tracks on 1" wide tape. Precise assembly ensures repeatability and long working life.
Accurate gap-alignment can be provided. Superior cross-talk rejection and good low-frequency response.
Ranges available for in-contact and out of contact use.

CLOSED CIRCUIT TELEVISION

ABOVE BLACK AND WHITE TELEVISION CAMERA MARK VI Uses the EMI 1" vidicon tube.
Bandwidth: 8 mc/s.
Linearity: Better than 2% for line and field.
Sensitivity: Full Camera Control Unit output with an illumination of 1 ft. candle (50% reflectivity with lens at F/2).
Full range of accessories, for remote operation, available.

RIGHT COLOUR TELEVISION Suitable for industrial, studio or medical applications. Three vidicon camera with a special optical system giving high sensitivity under difficult lighting conditions.
Available for 405, 525 and 625 standards.
Fitted with four lens turret.
For use with colour projectors or receivers.



STROBOSCOPES

STROBOSCOPE TYPE 6

LEFT Flash rate: 5-1000 flashes per second in four continuous ranges.
Accuracy: 1% of F.S.D.
Flash duration: 31μ sec to 8.5μ sec varying with rate.

STROBOSCOPE TYPE 3D

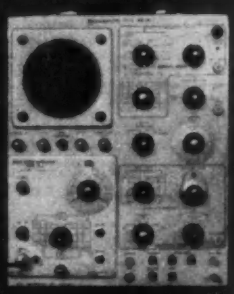
Flash rate: 5-100 flashes per second in two continuous ranges.
Accuracy: 1% of F.S.D.
Flash duration: 16μ sec to 9μ sec depending on rate.

STROBOSCOPE TYPE 5C

A portable hand-operated stroboscope. Flash rate: 10-100 flashes per second.
Accuracy: 10% F.S.D.

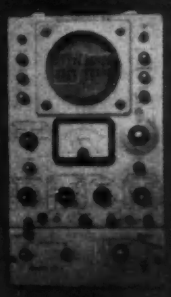
OSCILLOSCOPES

OSCILLOSCOPE TYPE WM16



Bandwidth: DC-40 Mc/s (± 3dB).
Maximum sensitivity: 50 mV/cm.
Sweep speeds: 20 mμs/cm-0·5 s/cm.
Sweep delay: 1μ sec-150 m sec.
Direct time and voltage measurement: ± 3%.
Built-in signal delay: 0.2μS.
Plus range of plug-in units.
Full range of attenuator probes from 5 : 1 to 100 : 1.

OSCILLOSCOPE TYPE WM8



Bandwidth: DC-15 Mc/s (± 3dB).
Maximum sensitivity: 50 mV/cm.
Sweep speeds: 50 mμs/cm-15 ms/cm.
Time measurement by dial: ± 2%.
Voltage measurement: ± 3% F.S.D by built-in voltmeter.

DISTRIBUTED AMPLIFIER TYPE 2C

Frequency range: 50 c/s to 100 Mc/s.
Maximum output: 100v pk-pk.
Gain: X 12.
Risetime: 5 mμ sec.

PULSE GENERATOR TYPE 1

Risetime: 1 mμ sec.
Pulse amplitude: +125v to —125v.
Pulse repetition rate: 50 to 150 cps.
Pulse width: 4, 50 and 100 mμ sec.

STROBOSCOPES

STROBOSCOPE TYPE 6

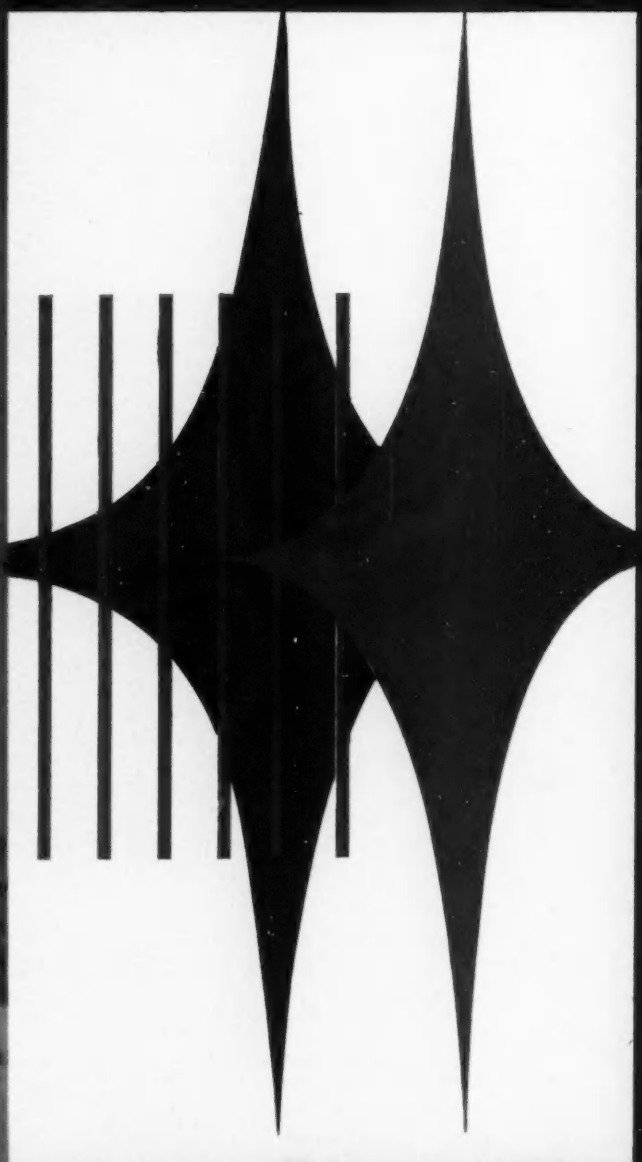
LEFT Flash rate: 5-1000 flashes per second in four continuous ranges.
Accuracy: 1% of F.S.D.
Flash duration: 31μ sec to 8.5μ sec varying with rate.

STROBOSCOPE TYPE 3D

Flash rate: 5-100 flashes per second in two continuous ranges.
Accuracy: 1% of F.S.D.
Flash duration: 16μ sec to 9μ sec depending on rate.

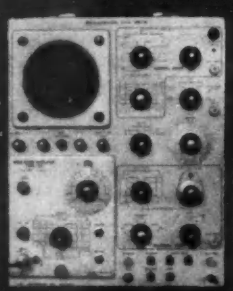
STROBOSCOPE TYPE 5C

A portable hand-operated stroboscope. Flash rate: 10-100 flashes per second.
Accuracy: 10% F.S.D.



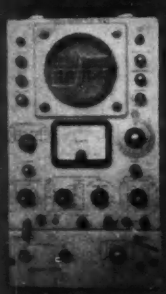
OSCILLOSCOPES

OSCILLOSCOPE TYPE WM16



Bandwidth: DC-40 Mc/s (± 3dB).
Maximum sensitivity: 50 mV/cm.
Sweep speeds: 20 mμs/cm-0·5 s/cm.
Sweep delay: 1μ sec-150 m sec.
Direct time and voltage measurement: ± 3%.
Built-in signal delay: 0.2μS.
Plus range of plug-in units.
Full range of attenuator probes from 5 : 1 to 100 : 1.

OSCILLOSCOPE TYPE WM8



Bandwidth: DC-15 Mc/s (± 3dB).
Maximum sensitivity: 50 mV/cm.
Sweep speeds: 50 mμs/cm-15 ms/cm.
Time measurement by dial: ± 2%.
Voltage measurement: ± 3% F.S.D by built-in voltmeter.

DISTRIBUTED AMPLIFIER TYPE 2C

Frequency range: 50 c/s to 100 Mc/s.
Maximum output: 100v pk-pk.
Gain: X 12.
Risetime: 5 mμ sec.

PULSE GENERATOR TYPE 1

Risetime: 1 mμ sec.
Pulse amplitude: +125v to —125v.
Pulse repetition rate: 50 to 150 cps.
Pulse width: 4, 50 and 100 mμ sec.

Overleaf the new Selection Charts for Klystrons and Photomutiplier Tubes.

details

Your new detachable short catalogue of

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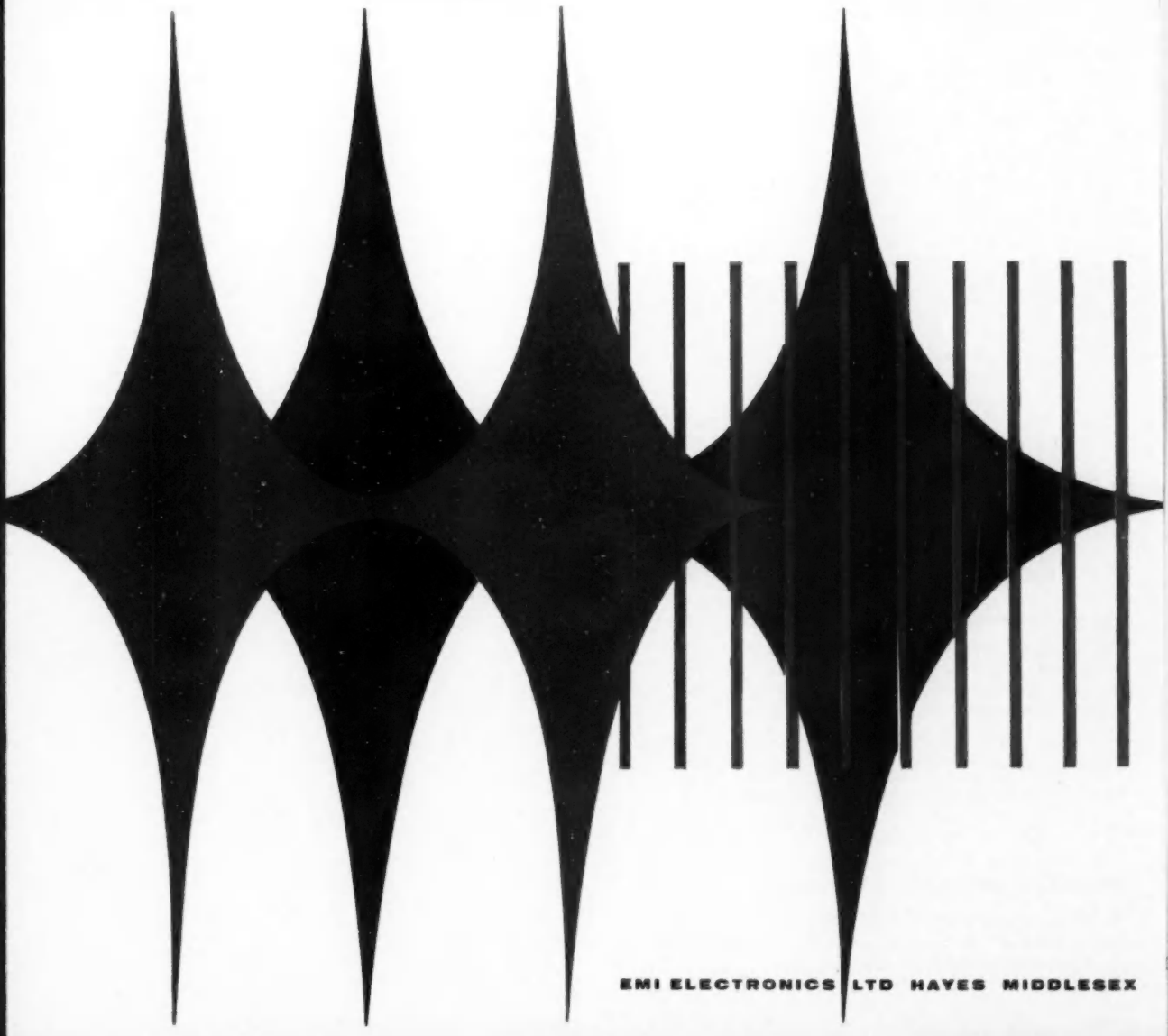


EMI ELECTRONICS LTD HAYES MIDDLESEX

NG

EMI

Photomultiplier tube selection chart

PHOTOCATHODE DATA

The range of spectral sensitivity is given with quantum efficiency (Electrons per photon) at points indicated. Tubes having given end-window cathode type are listed.

WAVELENGTH · Microns. 0 · 0·2 · 0·4 · 0·6 · 0·8 · 1·0 · 1·2

AgMgO surface in vacuo. 9603 Particle multiplier.

Developmental tubes with LiF windows.

Developmental tubes with Sapphire windows.

Au on fused Silica	6255G
Mg on fused Silica	6255Mg
SbCs on fused Silica	"S" Cathode on Silica. 6255S, 6256S, 9526S, 9552S
SbCsO on fused Silica	S13. 6255B, 6256B, 9526B, 9530Q, 9531Q, 9552B,
BiAgOCs on fused Silica	S10 on Silica. 9529B
SbNaKCs on fused Silica	Trialkali on Silica. 9558Q
AgOCs on fused Silica	Developmental S1 on Silica
BiAgOCs on U.V. glass	S10. Extended response. 9592B
SbCsO on U.V. glass	S11. Extended response. 9621B
SbNaK on glass 25μA/L	Bialkali. Cathode. 9607B. For operation up to 150°C.
SbCs on glass 40μA/L	"S" Cathode. 6097S, 9502S, 9514S, 9524S, 9536S
SbCsO on glass 70μA/L	S11. 6094B, 6097B, 9502B, 9514B, 9524B, 9530B, 9531B, 9536B, 9545B, 9578B, 9579B, 9583B, 9584B, 9593B, 9618B, (9623B
BiAgOCs on glass 30μA/L	S10. 6095B, 9554B
SbNaKCs on glass 150μA/L	S20. 9558B, 9578TA
AgOCs on glass 15μA/L	S1. 9553B

DYNODE CHARACTERISTICS

Tubes are made with dynode structures appropriate to their application.

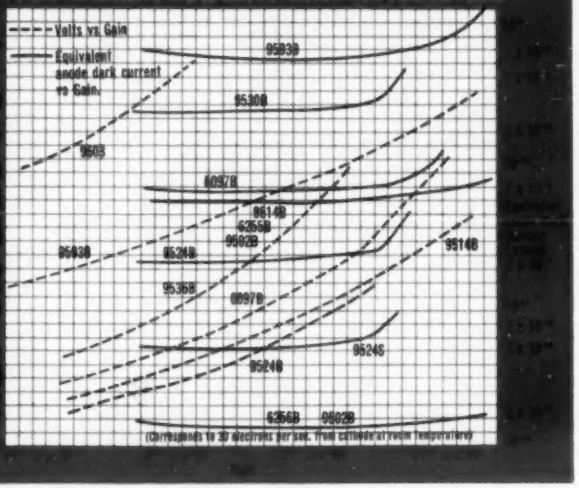
Box & Grid (Coated with SbCs). Give very high stage gain at low voltage and are used in small diameter tubes (e.g. 9524B) particularly for portable apparatus. Time characteristics are relatively poor, and peak anode currents are limited to about 50mA.*

Venetian Blind dynodes (SbCs Coated). Give good average gain and very low dark currents. The large diameter allows of good collection efficiency from the cathode. Rise times of 2" tubes are about 7 nanoseconds and peak currents up to 300 mA may be drawn.

Focused structures (AgMgOCs) give very good time characteristics, with rise times around 2½ nanosecs, but gain is relatively lower than the other types and dark current worse.

AgMgO dynodes (whether F or VB) made without Cs in the tube (e.g. 6255G, 9607) give low gains and require high voltage for operation. Dark Current in μA divided by overall sensitivity in Amps per Lumen gives equivalent Dark Current in Lumens and should be independent of gain. (*Note. Average anode currents are limited to 1mA max.)

GAIN & DARK CURRENT CHARACTERISTICS



Note: The dark current of a PM tube may be relatively high when the tube is first operated, but will quickly decrease during operation in the dark, and may go on decreasing for several days before reaching a limiting value.

ENVELOPE DIAMETER

½" 13mm	1" 25mm	2" 50mm	3"	5" 130mm	7"	10"	12" 300mm
	11BG 9524 9526 9529 9592 9600* 9621 (B14B)	10VB 9536 9552 9553 9554 (B14A)	10VB 9578 (B14A)	10VB 9579 (B14A)	11VB 9623 (B15B)		11VB 9545 (B15B)
		11VB 9584 (B14A)	11VB 9531 (B15B)	11VB 9583 (B14A) 9530 9618 (B15B)			
Developmental		6094** 6095 6097 (B15B)					
		9558 9607† (B19A)					
		13VB 6255 6256** 9502** 9514 (B15B)					
		14F 9593‡ (B19A)					

NOTES † AgMgO coated dynodes.

‡ AgMgOCs coated dynodes.

All other tubes have SbCs coated dynodes.

** 10mm cathode.

* Side Wall Sensitive 20cm² total cathode area.

B14A is a Diheptal base, all other bases are of glass.
PTFE Sockets are available for the glass base tubes.
The operation of PM tubes may be affected by magnetic fields and μ-metal shields are available.
PM tubes should not be operated at excessive light levels with voltage applied.
Dark current is dependent on operating temperature. The data given refers to 20°C. A reduction in temperature to −10°C will give a decrease of ca. 10:1.

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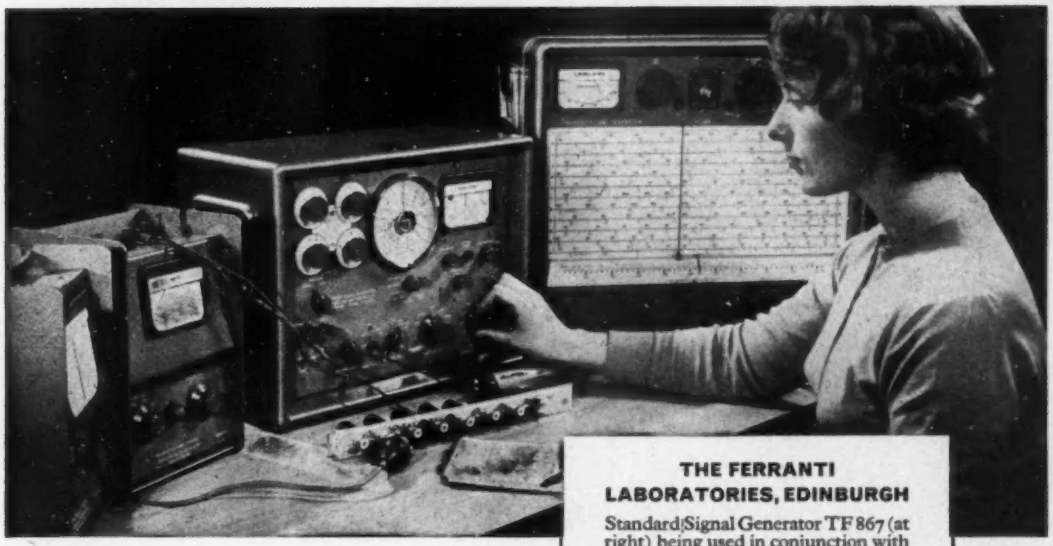

THE FERRANTI LABORATORIES, EDINBURGH

Standard Signal Generator TF 867 (at right) being used in conjunction with the F.M./A.M. Signal Generator TF 995A/5, and two Marconi voltmeters, to assess the performance of a C.W. Amplifier in the presence of an F.M. signal.

With a reputation to live up to, it pays to invest in the best. "There's safety in certainty" say Ferranti Ltd., and a look round their laboratories shows how much they rely on Marconi instruments. Very much in the picture is the Standard Signal Generator TF 867, a precision laboratory instrument covering the frequency range 15 kc/s to 30 Mc/s. Features include a high quality r.f. output, a built-in crystal calibrator, automatic level control, and sinewave a.m. monitored and variable to 100%. An alternative version, the TF 867/2, has special features of particular value when testing narrow-band communication receivers. For full details of these instruments write for Leaflet J 183.

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REPRESENTATION IN 68 COUNTRIES

TC 183

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Ediswan Mercury Vapour Grid Controlled Rectifier Type 21 N12

This Ediswan Valve is specially designed for controlling the HT supply of High Frequency heating equipment. With a PIV rating of 10 kV at 3 amps plus a maximum surge rating of 20 kV PIV, it fills a gap not previously covered by any other valve of this type. It is surprisingly small for a valve with such a power handling capacity, and as it has been produced specifically for this work it costs less than any other available type that might be adapted for the purpose.

BRIEF SPECIFICATION		
RATINGS	Heater Voltage (Volts)	5±5%
	Heater Current (nominal) (Amps)	5
	Absolute maximum PIV surge rating (kV)	20
	Maximum Mean Cathode Current (Amps)	3
MOUNTING POSITION	Base Down (Vertical)	
MAXIMUM DIMENSIONS	Overall Length 248 mm Diameter 51 mm Seated Height 240 mm	

If you want to know more about this valve and discuss its application to your own equipment—write to us

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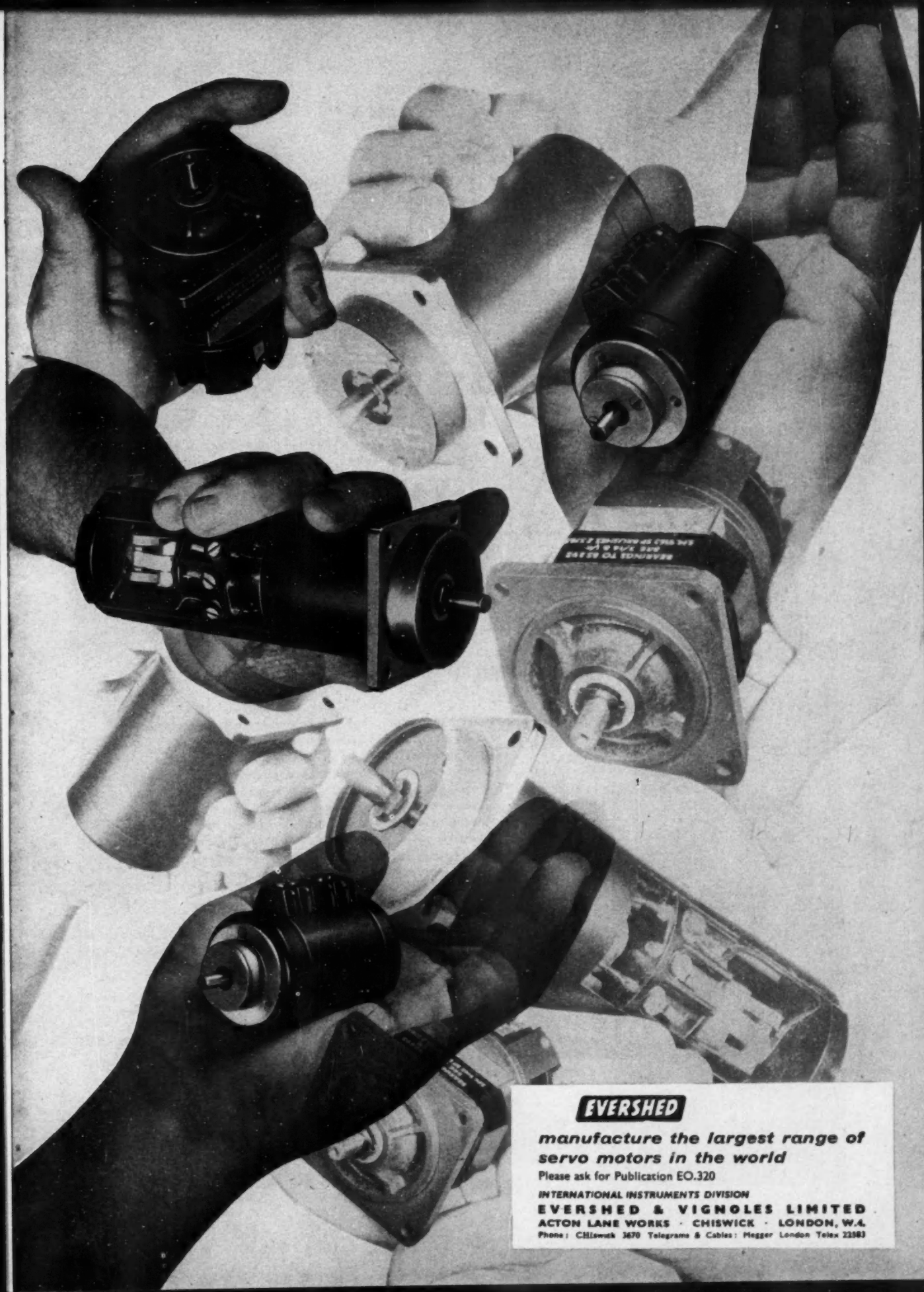

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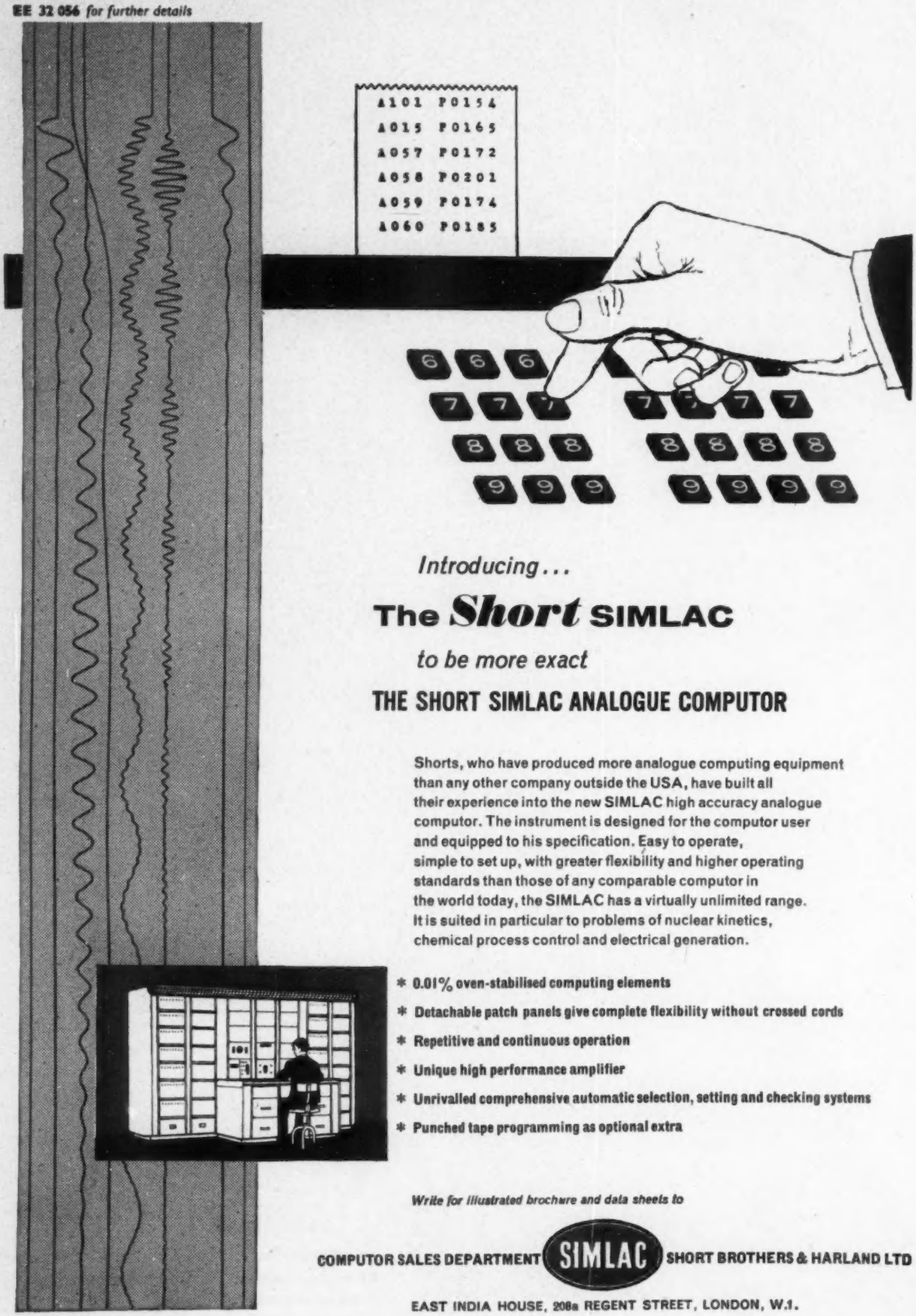

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* Unrivalled comprehensive automatic selection, setting and checking systems
* Punched tape programming as optional extra

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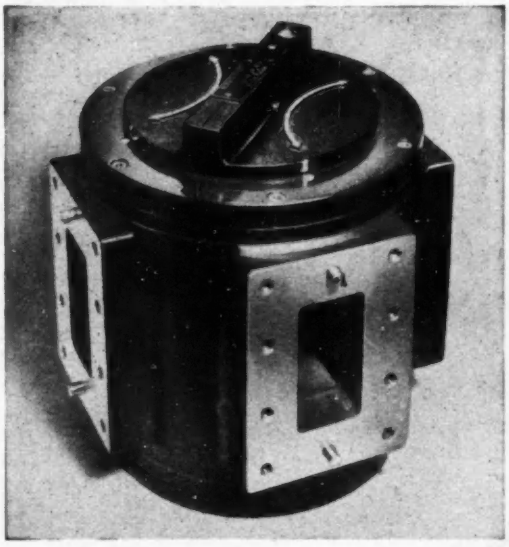

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The range of grade one microwave instruments produced by Decca Radar Limited is continually being improved and augmented. One of the latest additions is a WAVEGUIDE SWITCH of advanced design available in most of the popular waveguide sizes. It is suitable for either hand or mechanical operation.

These efficient modern waveguide switches are of the four port, two channel rotating drum type. Their principal design features are listed on the right.

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- High power handling capacity unpressurised.
- Good match over the whole waveguide frequency band.
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- Rugged construction.
- Designed for both normal atmospheric and high pressure operation.
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DR 127

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JLT instruments for industry

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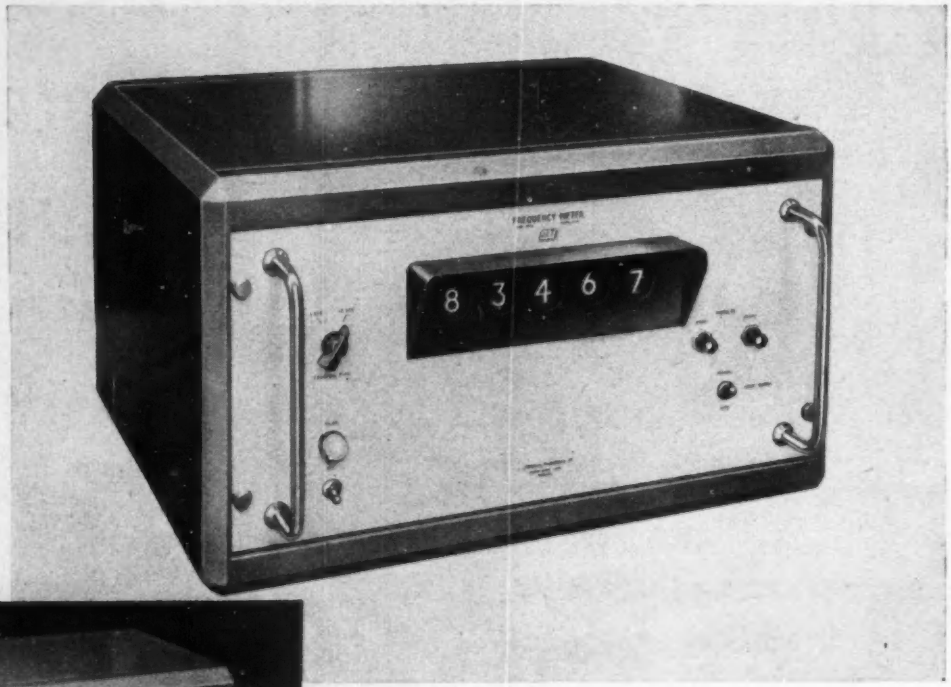
Series 1765 Mark II



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available with additional remote indicator facilities

- Brilliant digital display clearly readable at a distance of 30 feet.
- Counting speeds to 100 kc/s (5 digits) or 10 kc/s (4 digits), to an accuracy of ± 1 count, ± 0.005%
- When used in conjunction with a magnetic or photo-electric pick-up enables direct readout in revolutions per minute.

M.2

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R-C Oscillator Type TF 1101

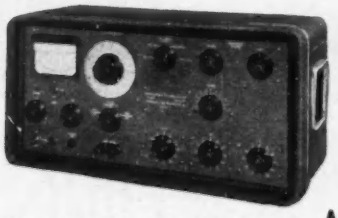
A compact general-purpose oscillator giving a low-distortion output of ¼ watt max. into 600 ohms. Frequency range 20 c/s to 200 kc/s. Output level indicated by panel-meter and calibrated attenuator. A band-pass filter provides for a 1-kc/s output of very low distortion.

Audio Tester Type TF 894A

The TF 894A covers from 50 c/s to 27 kc/s. It comprises a heterodyne oscillator and 0- to 50-dB, 600-ohm attenuator combined with a three-range a.c. voltmeter which is available for external use. Output: 2 watts maximum at 600, 15, and 3 ohms. Voltmeter ranges: 80, 8, and 4 volts full-scale.

A.F. Power Meter Type TF 893A

A wide-range absorption-type power meter for use in the frequency range 20 c/s to 35 kc/s. The power measurement range is 20 μW to 10 watts and the input impedance can be set to any of 48 different values between 2.5 ohms and 20 kΩ.



Distortion Factor Meter Type TF 142F

Measures total spurious content, up to 30 kc/s, of inputs within the fundamental frequency range 100 c/s to 8 kc/s. Distortion measurement range: 0.05 to 50%. The input can be at any level between 500 mV and 500 volts.

A.F. Power Meter Type TF 1347

A sensitive, accurate, direct-reading instrument. Its ten power ranges, covering 10 μW to 6 W, and 5½-inch meter provide excellent discrimination. Impedance range: 2.5Ω to 20kΩ in 11 steps. Frequency characteristic substantially flat from 50 c/s to 20 kc/s.

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Gives amplitude and frequency of individual components of either audio signals or the modulation envelopes of r.f. signals up to 500 Mc/s. Its a.f. range is 20 c/s to 16 kc/s and its amplitude measurement range is 30 μV to 300 volts.

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TC 172

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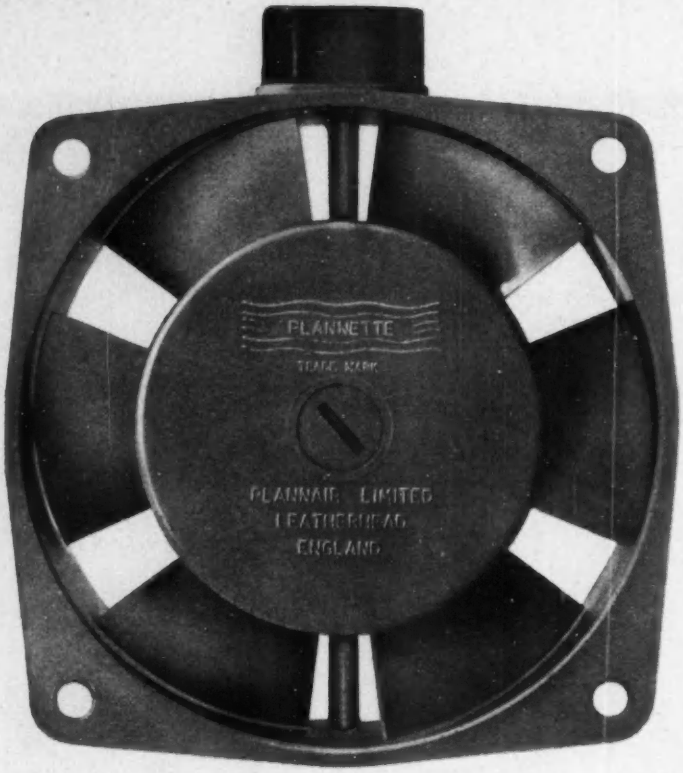

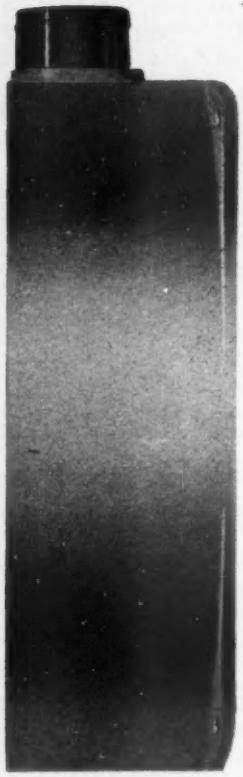

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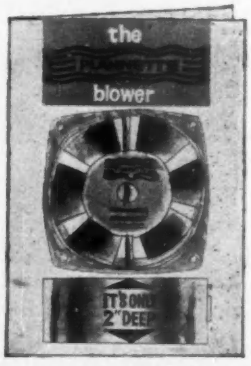

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2,700 r.p.m.:	1,400 r.p.m.:
4½″ delivers 80 c.f.m. at .15 s.w.g.	4½″ delivers 40 c.f.m. at .04 s.w.g.
6″ delivers 150 c.f.m. at .25 s.w.g.	6″ delivers 75 c.f.m. at .06 s.w.g.

The motors are a.c. and may be arranged either for 230V 1-ph 50/60 cycles or 110V 1-ph 50/60 cycles.

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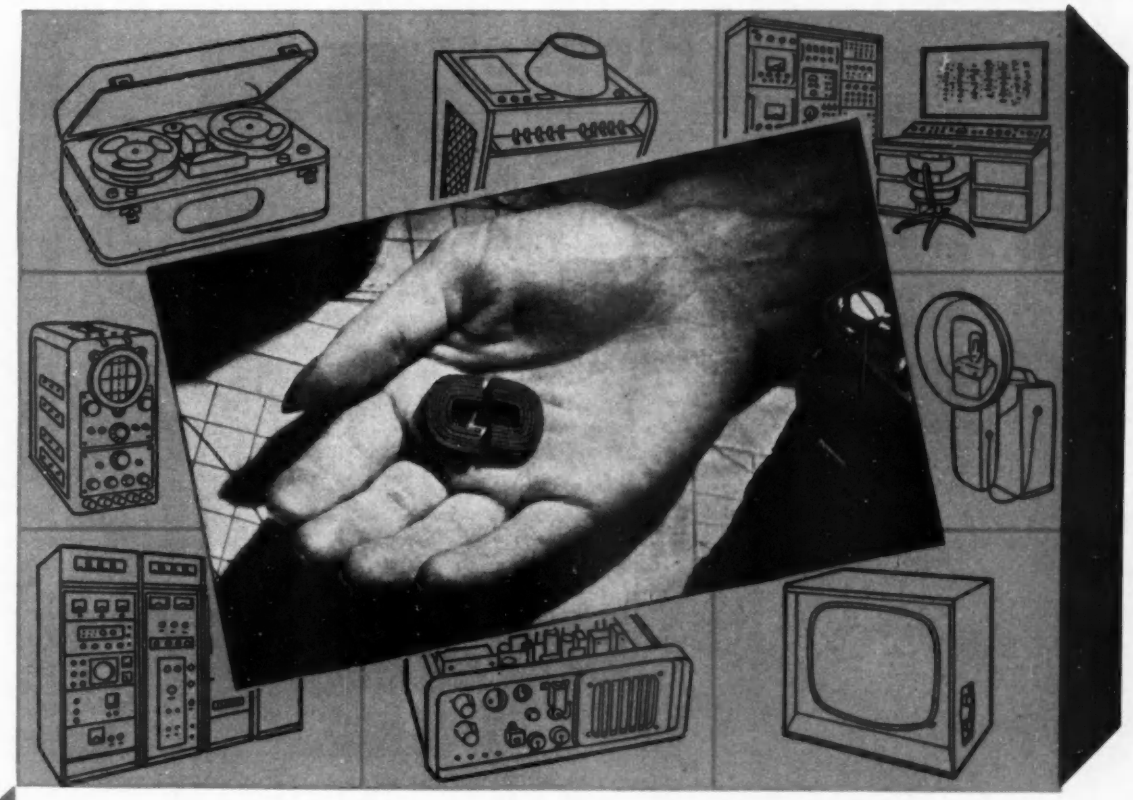

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The full range of 'C' cores in ·013″, ·004″ and ·002″ grain-oriented steel strip complies with the requirements of the Standard Interservice range (RCL.193). Special cores can also be supplied on request.

'ENGLISH ELECTRIC' 'C' cores are suitable for use in oil filled, open type, or resin cast transformers. Clamping frames and other accessories are available and manufacturers can obtain many of their component requirements from 'ENGLISH ELECTRIC'.

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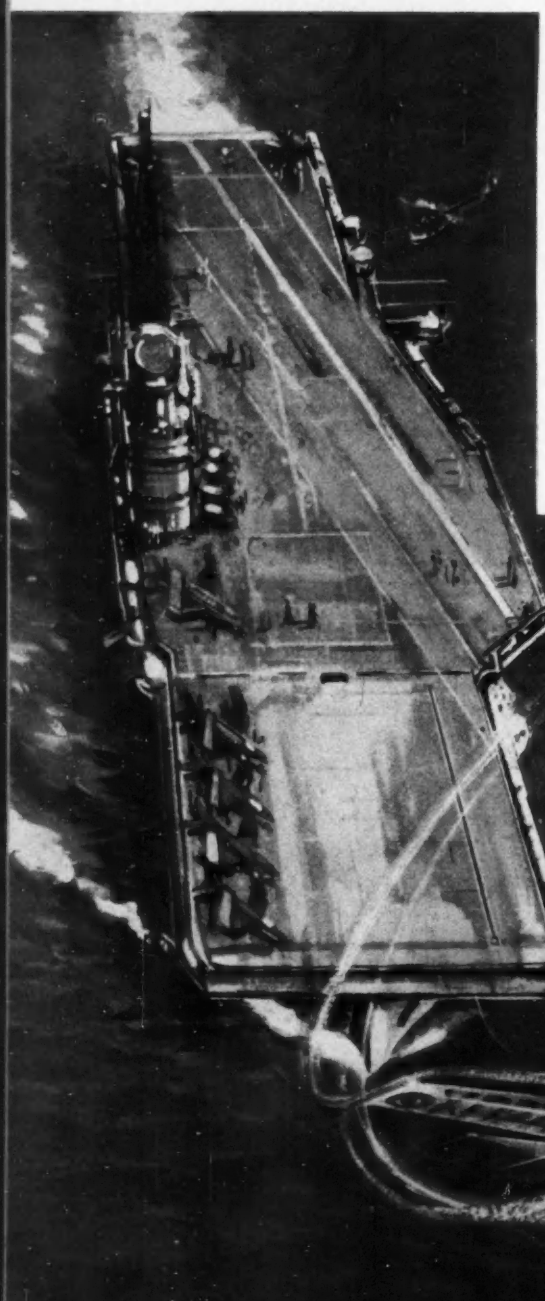

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Telecommunications Division

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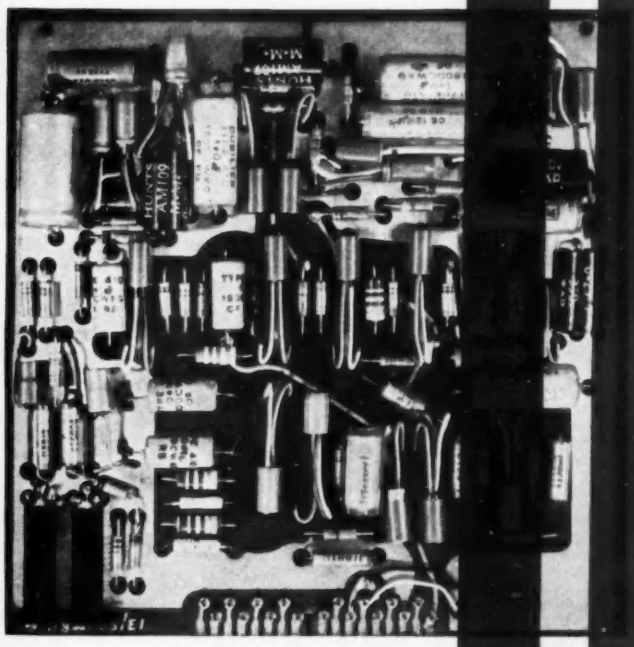
modular instruments for industrial process control and data handling



This Operational Amplifier is built on a 7 inch x 7 inch printed wiring board for easy incorporation into other equipment. Usually it plugs in but for extra reliability it can be wired in.

OPERATIONAL AMPLIFIER

The Amplifier can be used for differentiating, integrating, linearising, analogue to digital, voltage to digital and frequency to voltage conversion. It is one of the basic circuits in the Dataflex range and is used in a number of Dataflex Units.

Note these features:—

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- **Extremely low input voltage and current drift**
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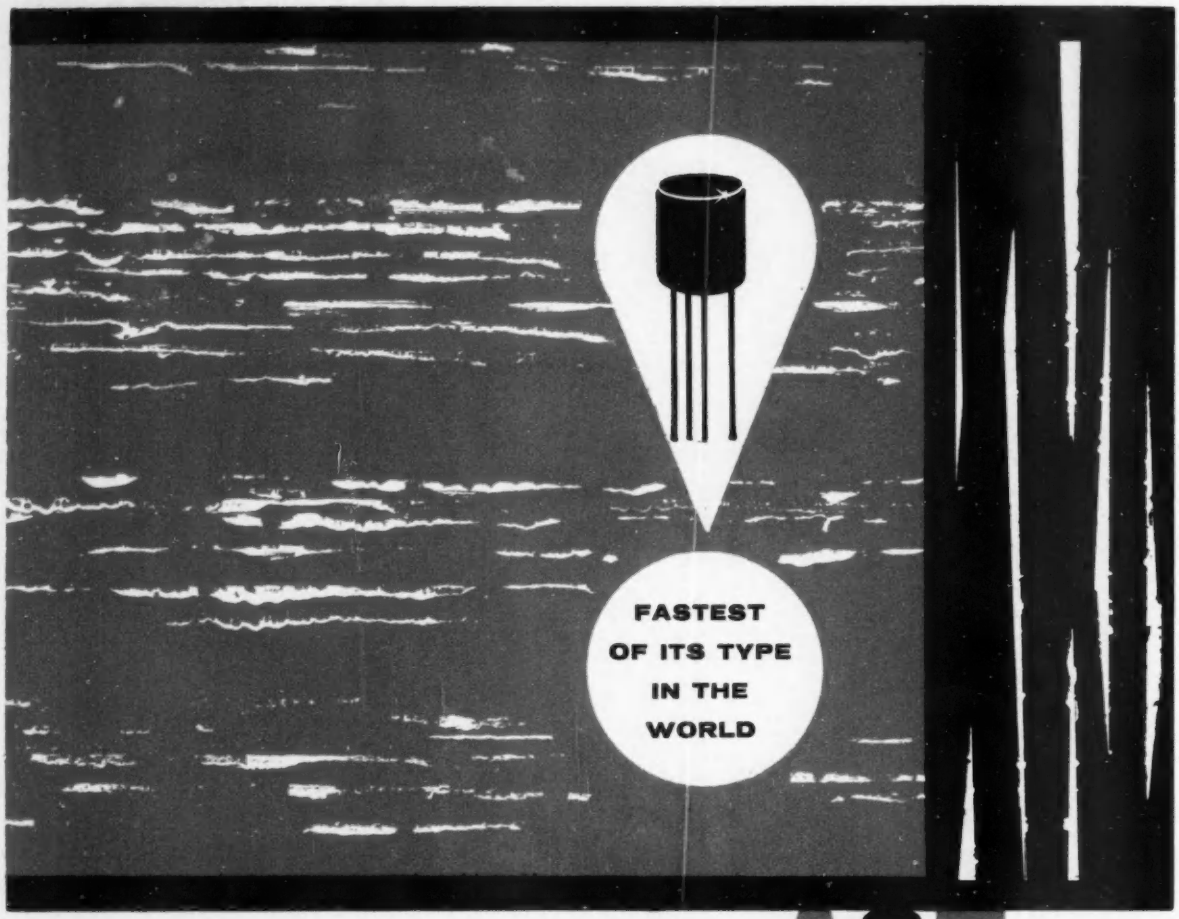
ER16 *(FORMERLY ERICSSON INSTRUMENT DIVISION)*



NEW MULLARD AVALANCHE TRANSISTOR

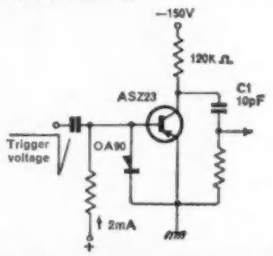
ASZ 23

Today you can specify a truly *dependable* avalanche junction transistor, for use in very high speed circuits. It is the Mullard ASZ23—a new *purpose-made* transistor that is manufactured by the Mullard alloy diffusion technique to give complete reliability of the avalanche mode. Mullard experience in the development of alloy diffused transistors has made possible the production of this high avalanche performance p-n-p junction transistor at a realistic price.

Here is a transistor to give the designer tremendous scope. The ASZ23 opens up a new field of nanosecond pulse techniques. A typical application is in the sampling oscilloscope circuit shown alongside.

Supplies of the ASZ23 are immediately available.

60 mA pulse with rise time of 1 nanosecond



A typical method of obtaining a predetermined sampling pulse by means of the ASZ23.

ASZ 23 Alloy Diffusion p-n-p Junction Transistor

Absolute Maximum Ratings

Collector current ic (pk) max	100 mA
Reverse emitter-base voltage V_{eb} max	−2.0 V

Temperature Ratings

Storage temperature limits	−55 to + 75°C
Maximum junction temperature	75°C
Junction temperature rise above ambient	0.6° C/mW
Junction temperature rise above case	0.5° C/mW

Typical Characteristics

at T junction=25°C	
V_{cb} turnover at I_{co}=1mA, Ie=0,	−24V
Rise time of output pulse in circuits shown	1ns

● *If you would like more detailed information, please write to the address below:*

Mullard **another ALLOY DIFFUSION transistor**

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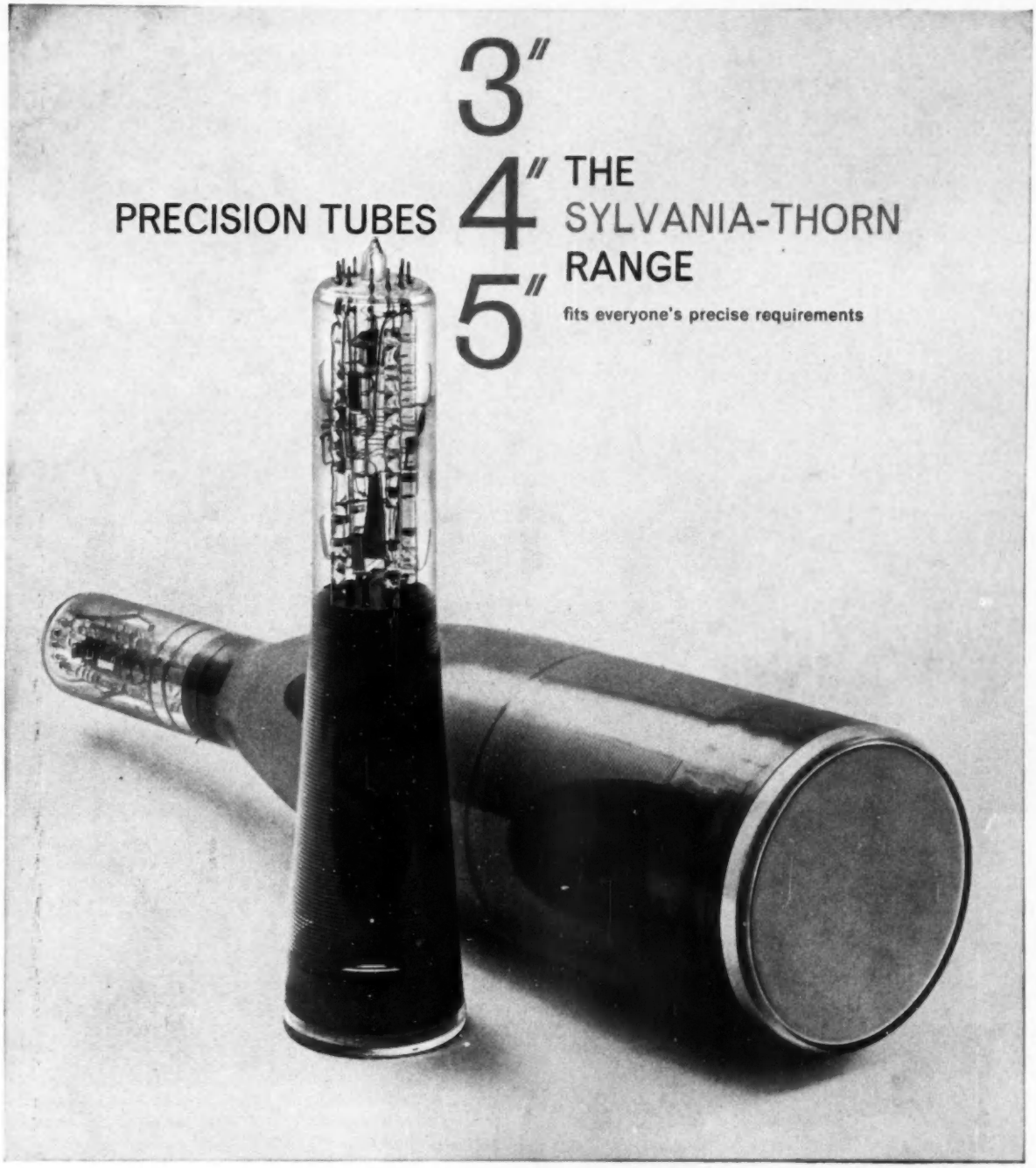
MI330



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MAIN TYPES (Typical Operating Conditions)

Face Diameter	5″	5″	5″	5″	5″	4″	4″	3″
Type No.	25SC	SE5A	SE5B	SE5D	SE5E	SE4A	SE4B	SE3A
Final anode voltage & PDA Ratio	12 4.8	10kv 6.67	10kv 6.67	10kv* 12	10kv 12	8kv 4	4kv 4	4kv 4
Screen Area cms x cms	8 x 10	6 x 10	4 x 10	4 x 10	6 x 10	5 x 8	5 x 8	5 x 6
Y sens. v/cm	15	10	7	3.5	5.5	15	7.5	7.5
X sens. v/cm	33	30	30	14	14	48	25	27

* at 7.5kv Sy 2.50 v/cm Sx. 10 v/cm Sensibility better than 0.14 v/line width

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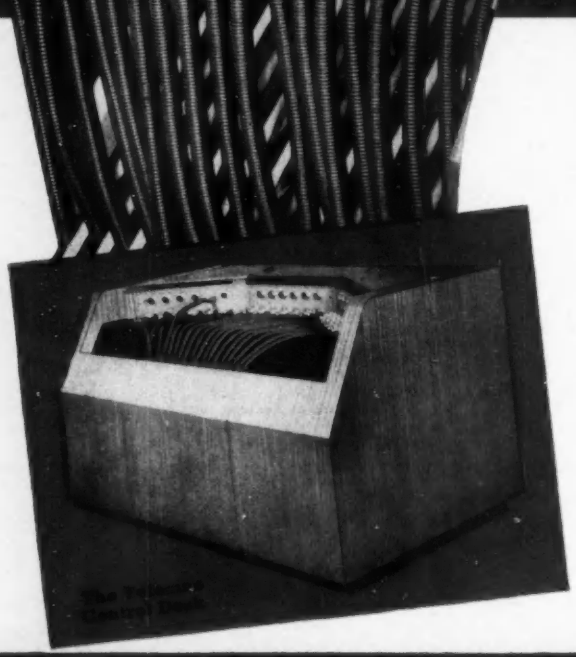
—in the New Television Centre, London



The use of Conflex conduit system on the Telecine Routing Desk at the B.B.C.'s new Television Centre is a completely new approach to installations of this nature. Many troubles that are normally associated with circuit changing are completely eliminated.

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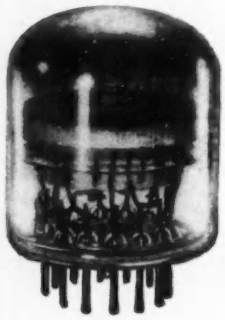
now, just one small tube counts selects indicates



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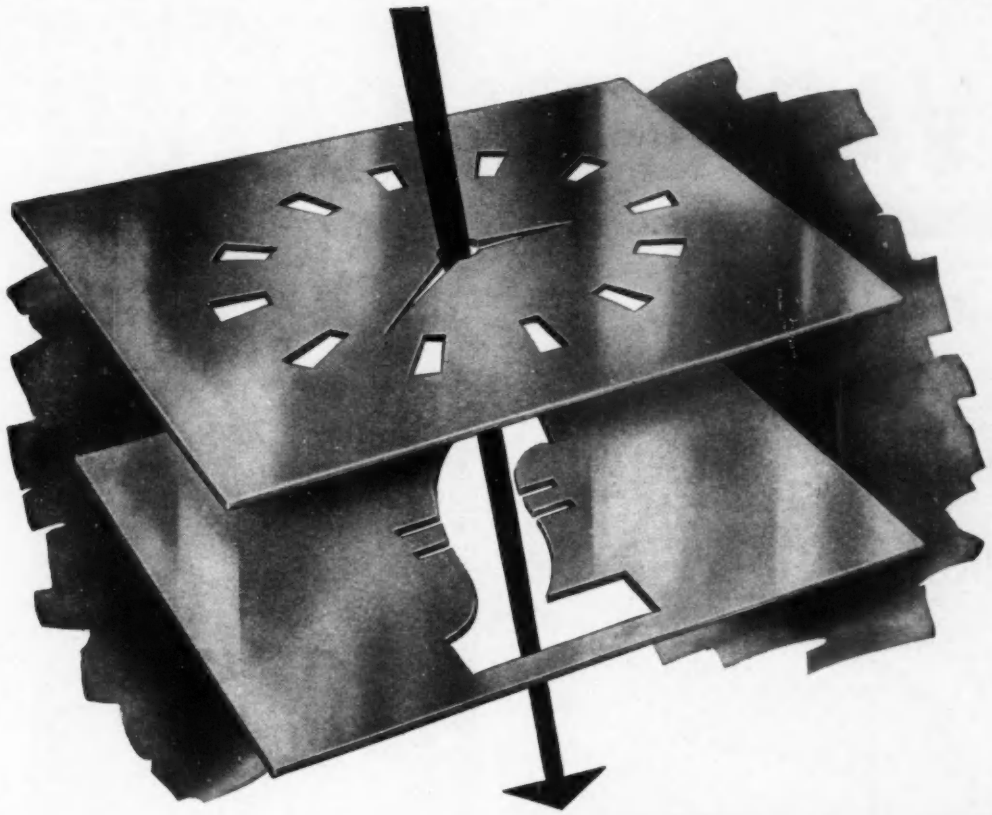

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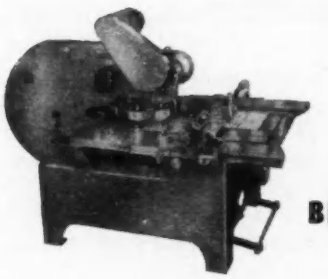

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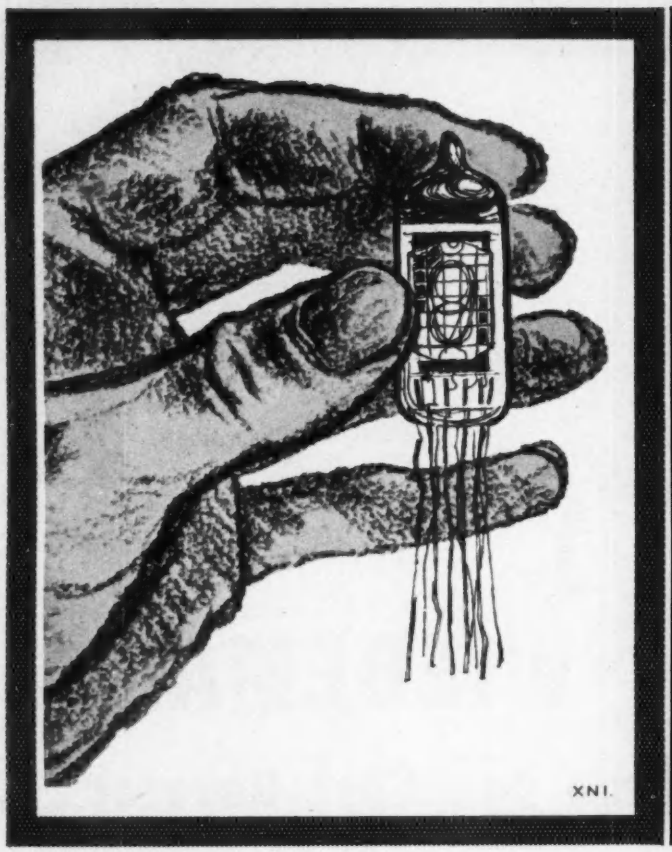

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✳ Hivac Numicators have all the normal advantages of neon indicator lamps—low consumption, low temperature operation, and freedom from risk of sudden failure.

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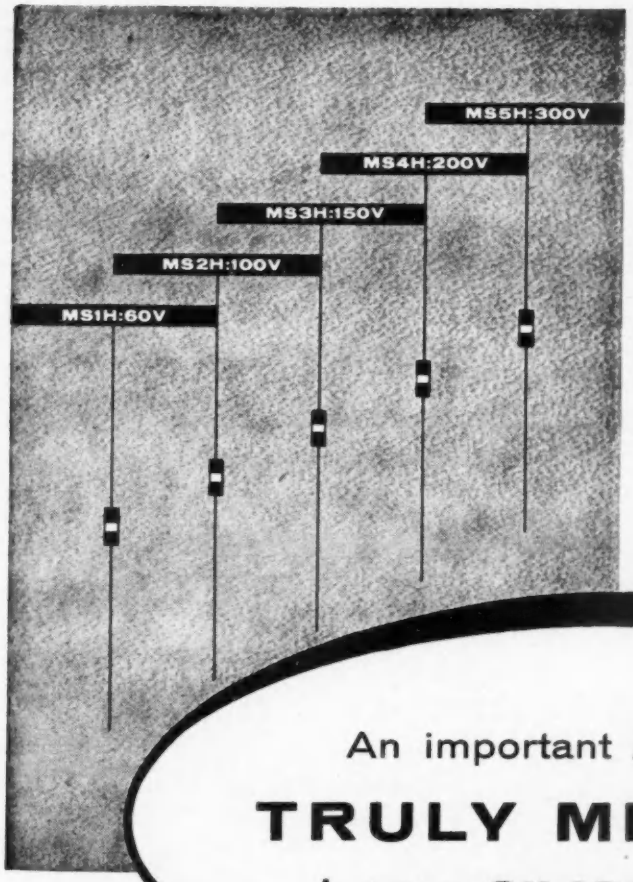

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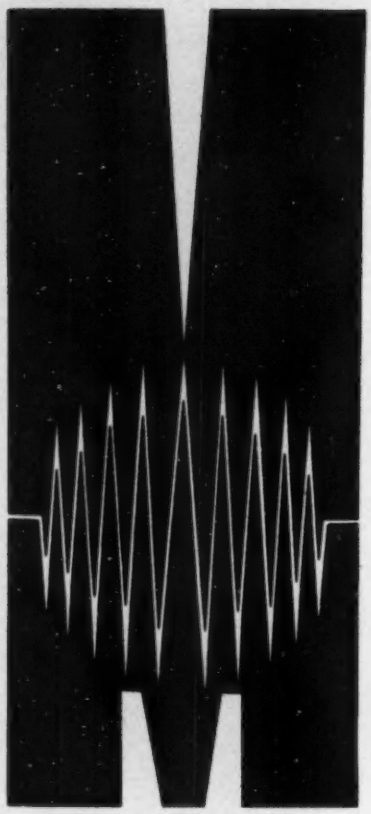

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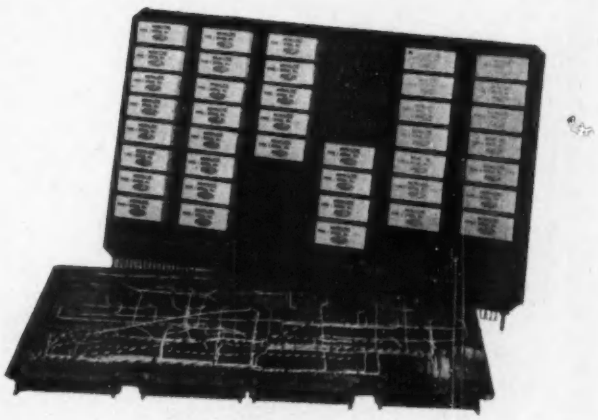

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'Electrosil' resistors contribute towards the high efficiency and reliability of the Xeronic Printer and are being specified in increasing quantities by manufacturers of quality equipment.

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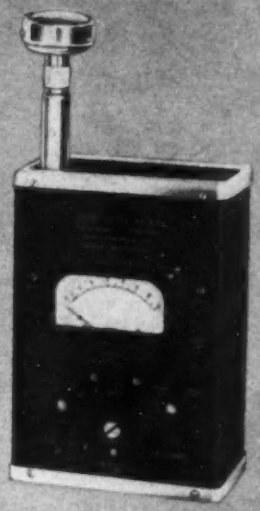

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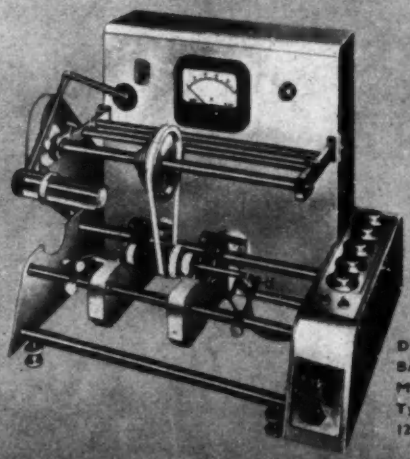

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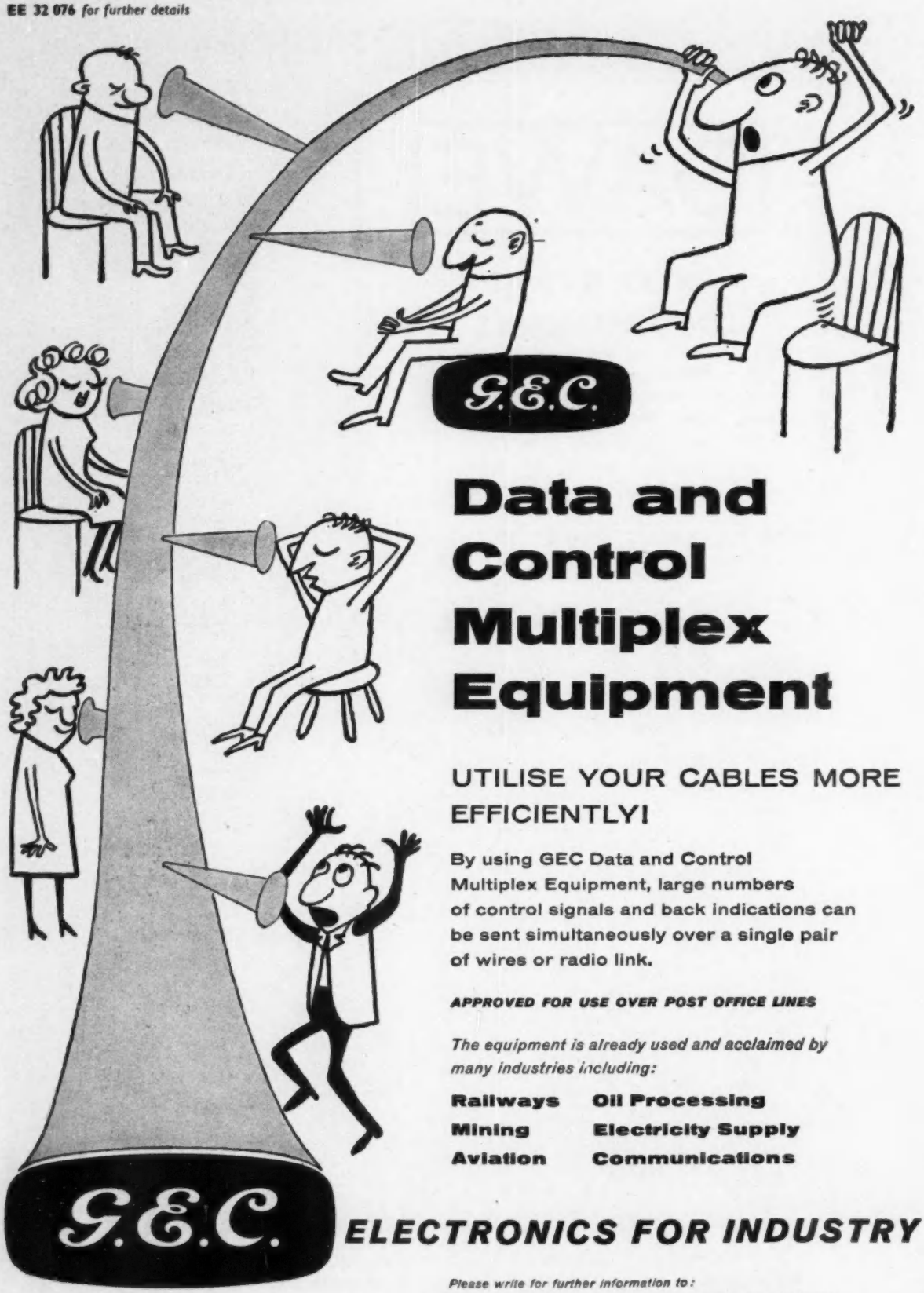

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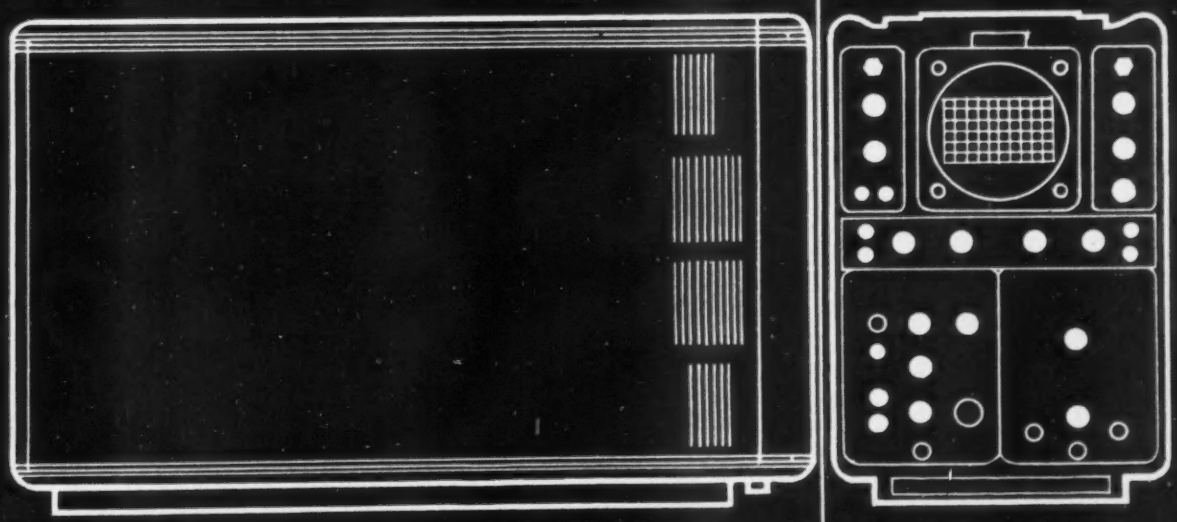

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1 d.c. to 60Mc/s at 50mV/cm

2 Full 6cm vertical display

3 Rise time 6-7 nanoseconds

4 Accepts wide range of X and Y plug-in units

5 Average price (U.K.) £650 according to plug-in units supplied

6 British manufacture . . . of British components

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COSSOR INSTRUMENTS

COSSOR MODEL 1076

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Heater Supply: Transistor stabilised DC to drift and hum sensitive circuits

Thermostatic switch provides protection against excessive temperature rise

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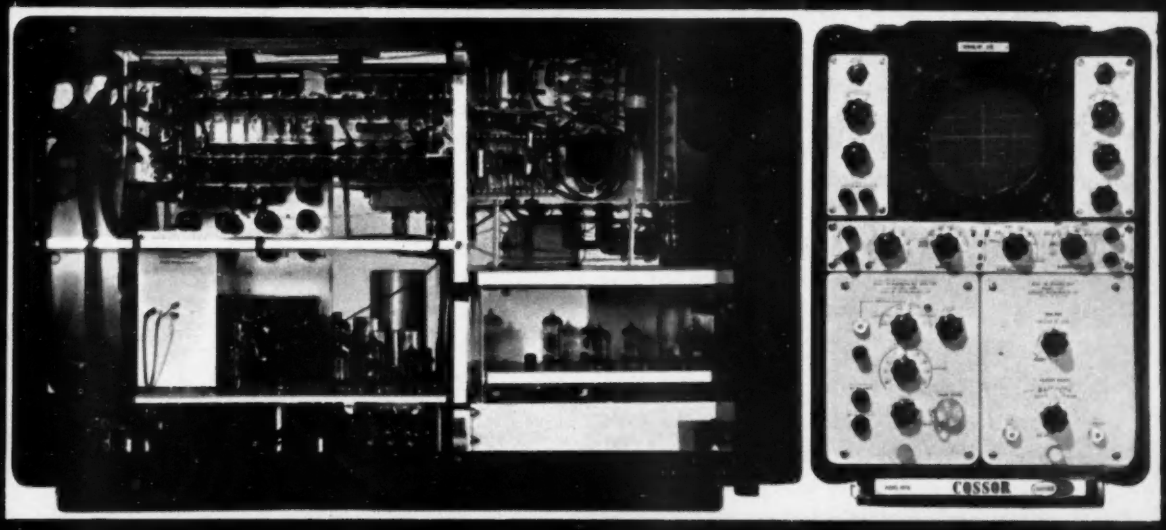

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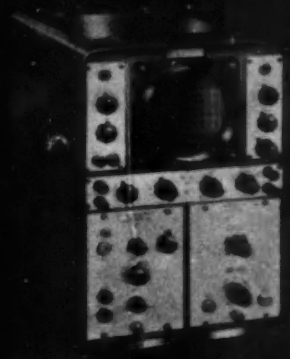

Y Amplifier input impedance matching to 50Ω, 75Ω as well as 1MΩ, 30nF all ranges

why Cossor Model 1076 is acknowledged the best Oscilloscope

A unique variety of exceptional facilities is for the first time available in the one oscilloscope. To meet any of your requirements, simply insert the appropriate plug-in units from the following range.

- **Wide band pre-amplifier d.c. — 60 Mc/s (-30%) at 50 mV/cm 2-3 cm linear output as 100 Mc/s** *plug-in unit Type 1078*
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I require technical representative to call

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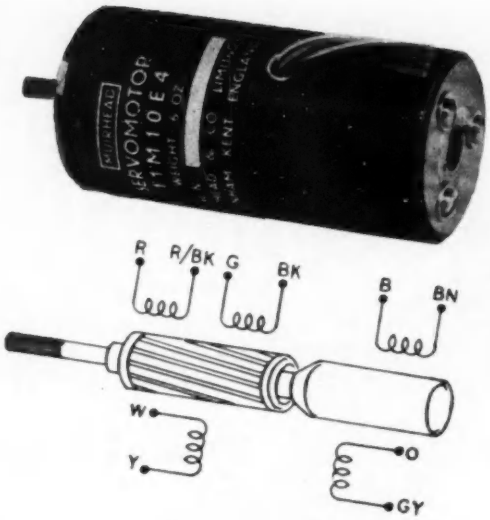

50:1
Output to
Null Ratio

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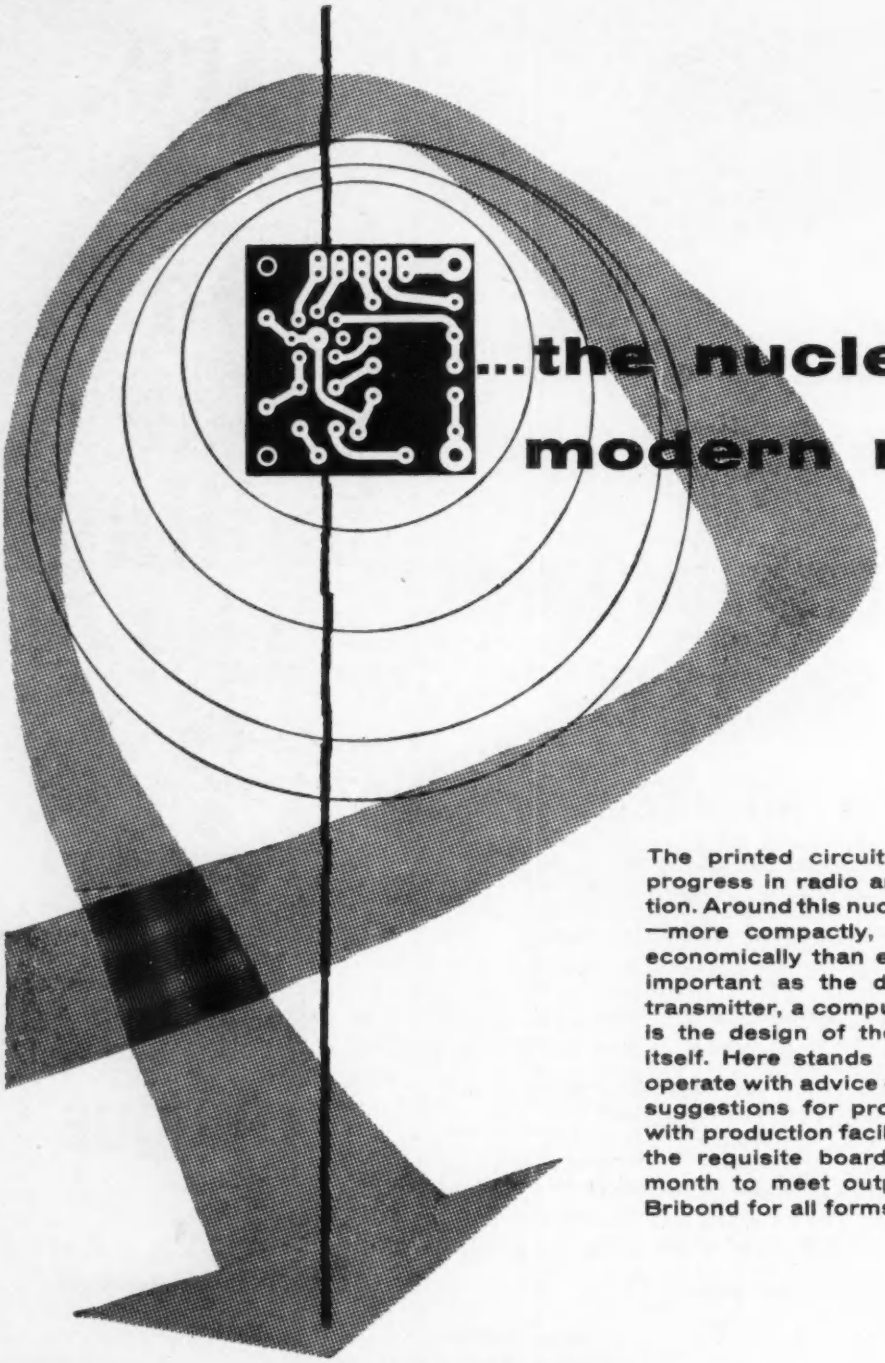

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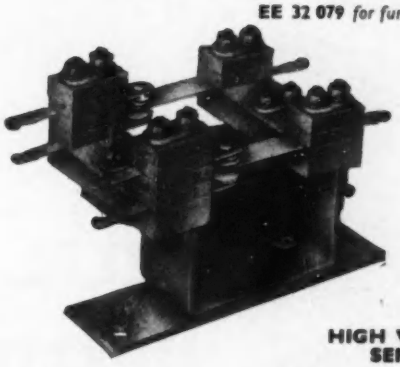

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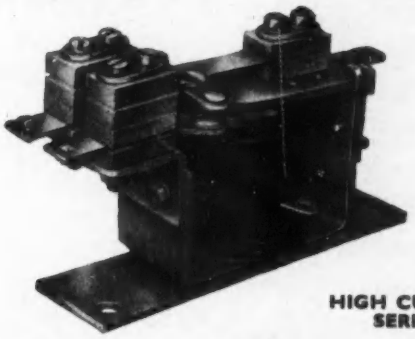

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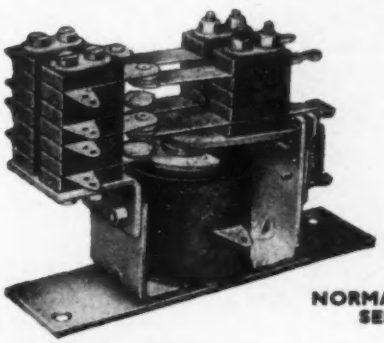

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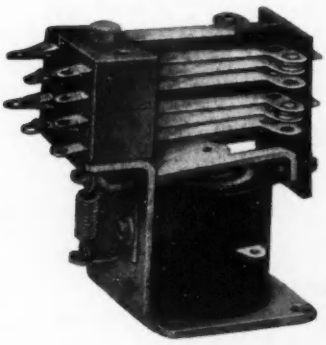

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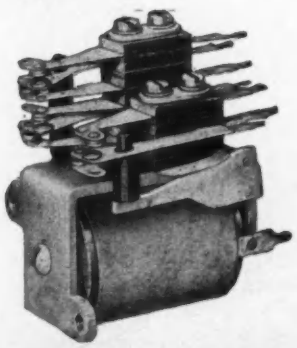

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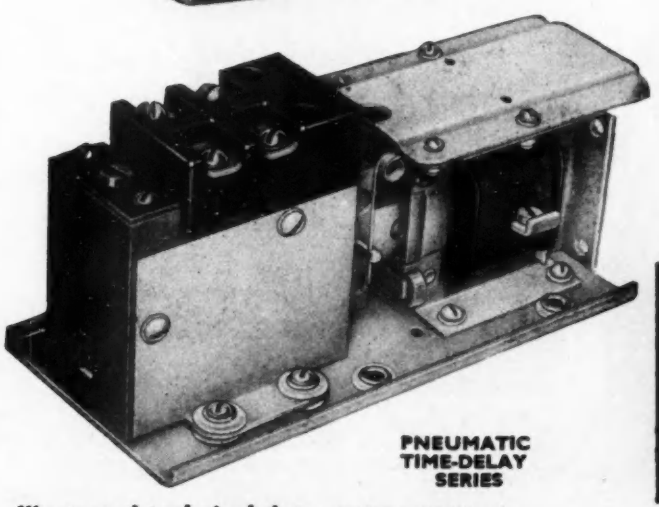

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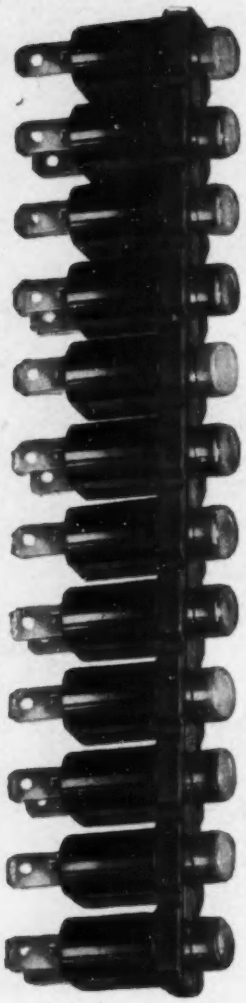

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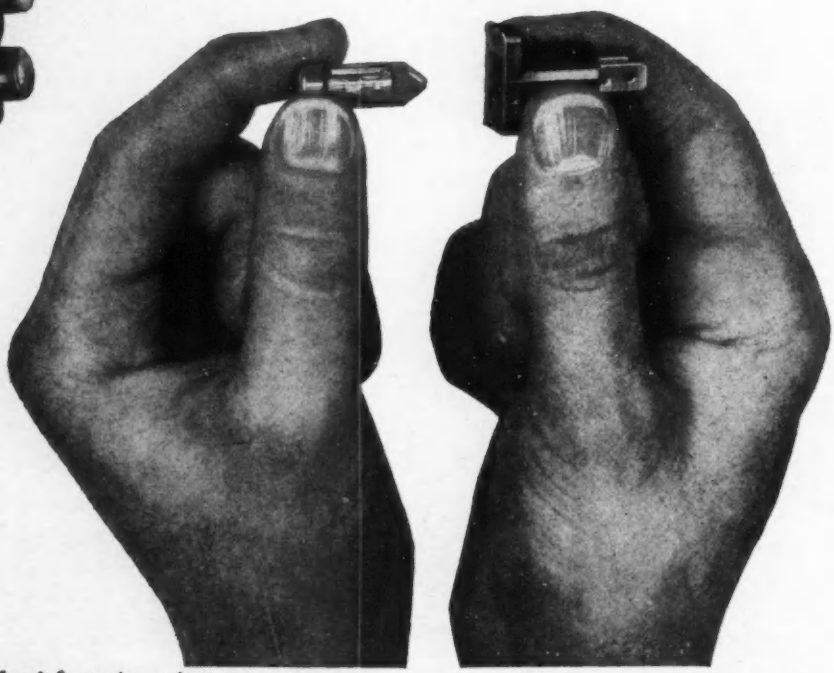

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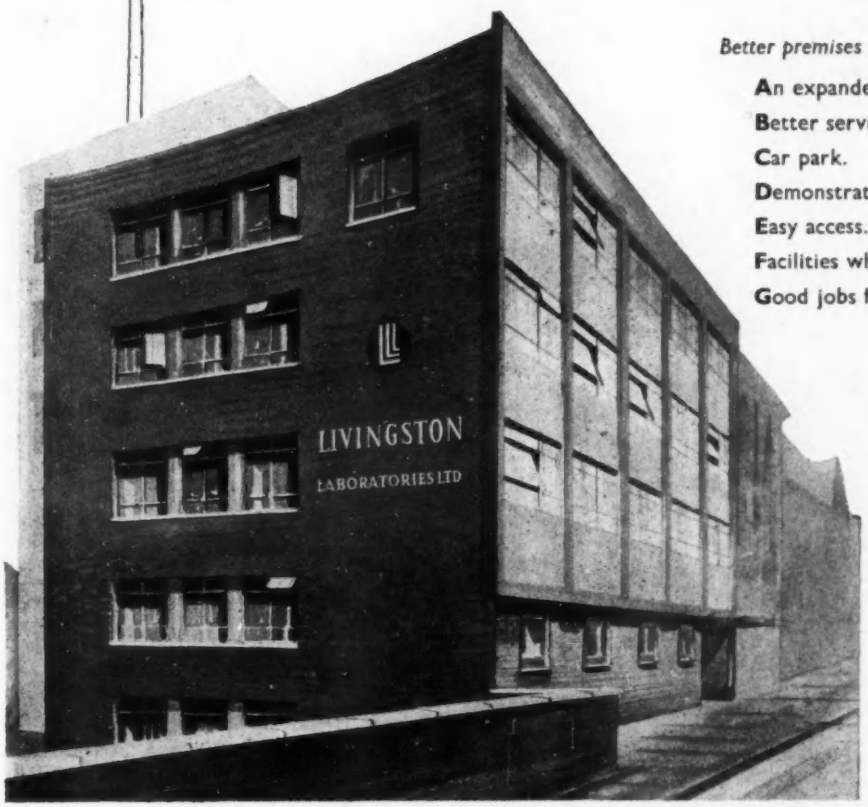

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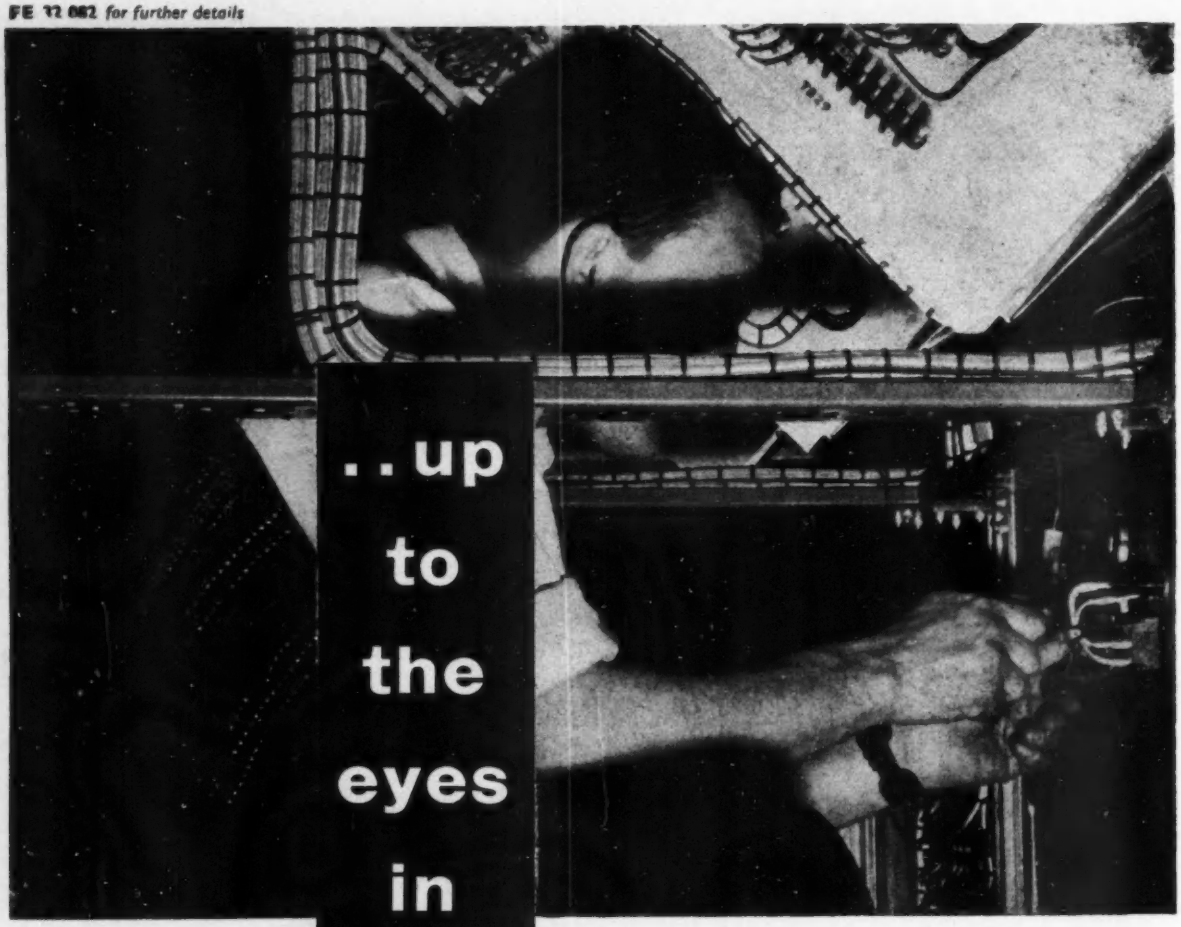

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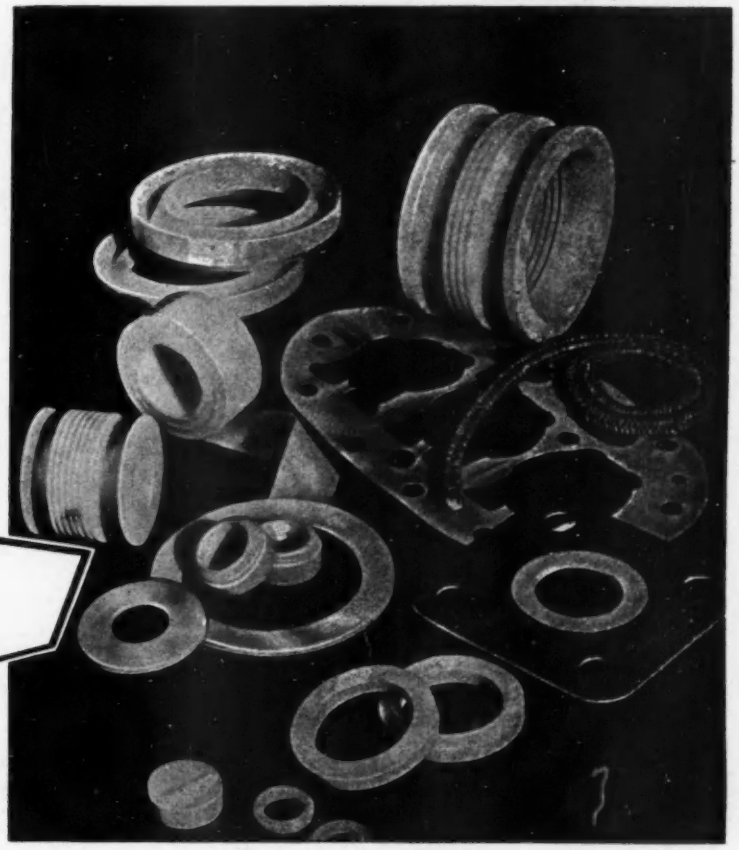

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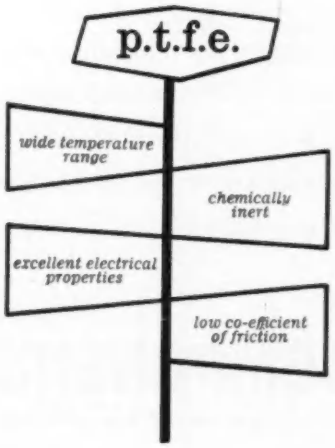

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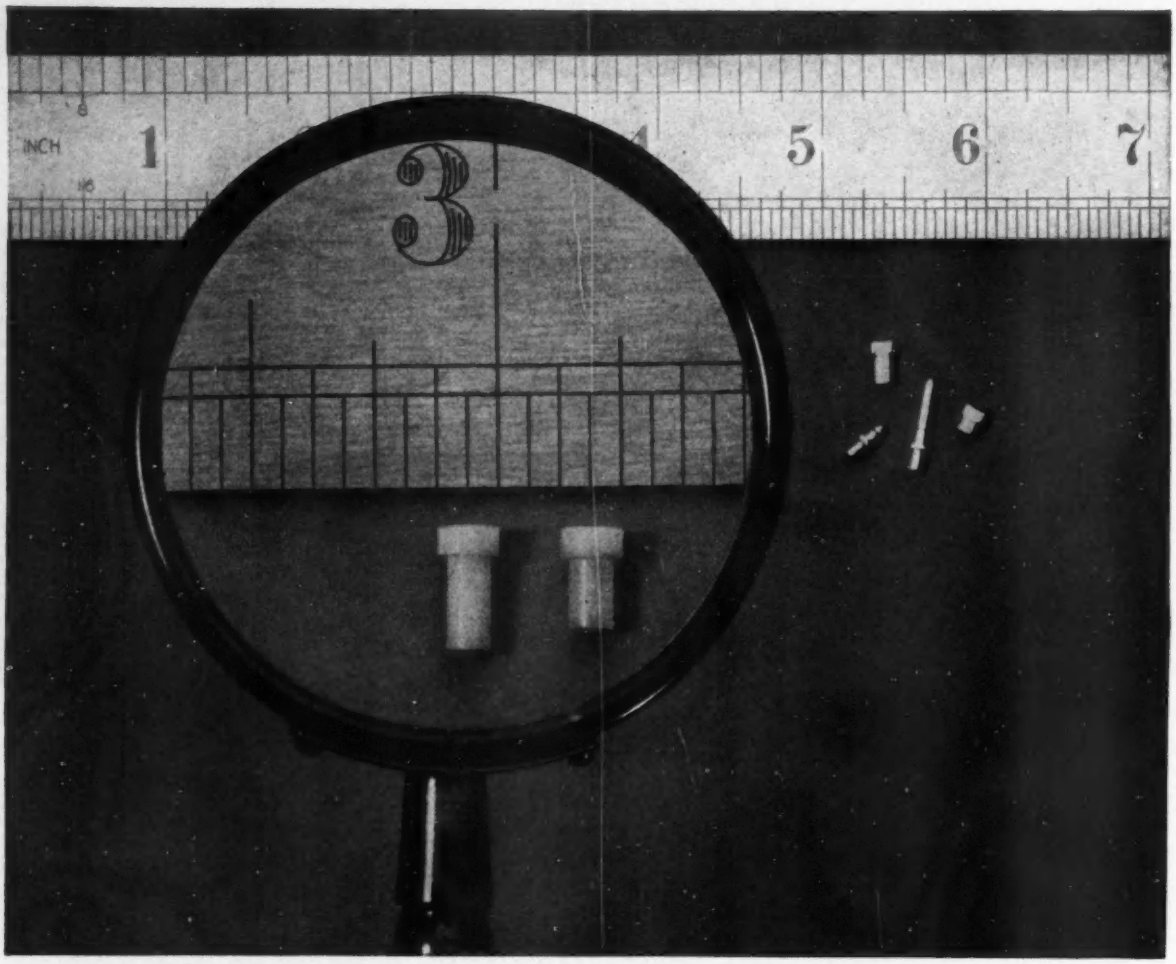

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Conforms to BS.415

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- **Robust phenolic moulding.**
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Write for fully descriptive leaflet, P.518

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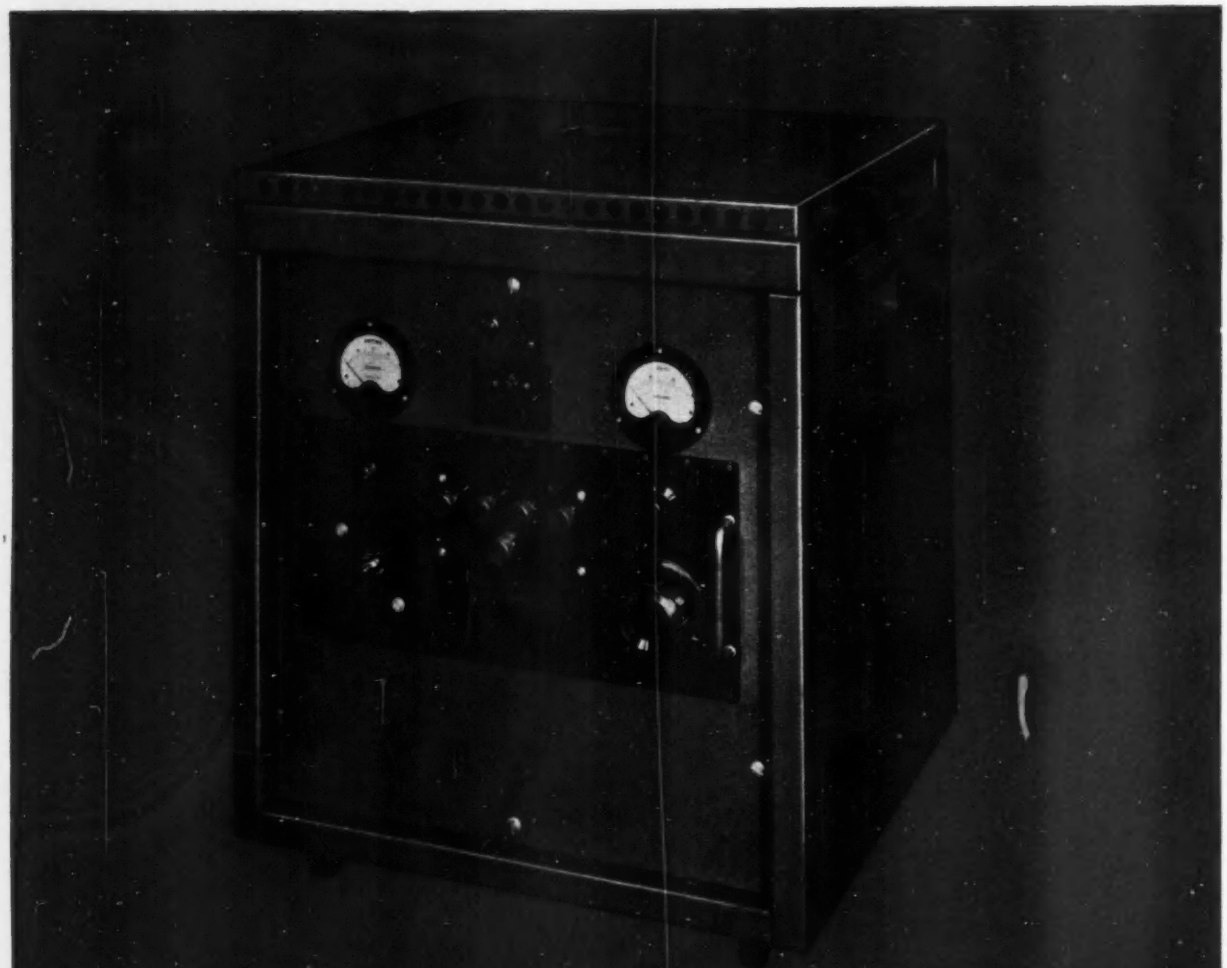

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● Stability ± 0.3% of the maximum voltage of the instrument.

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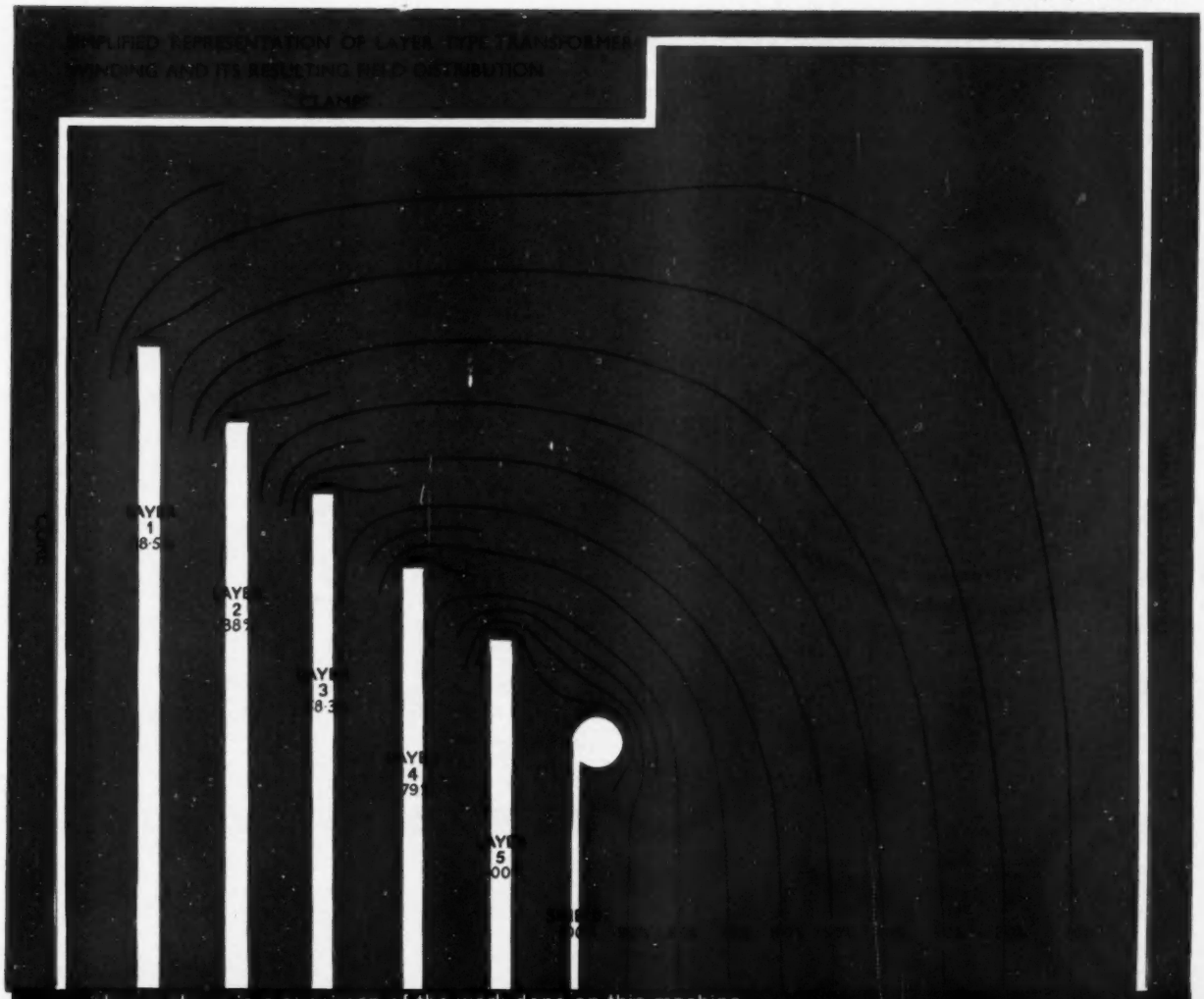
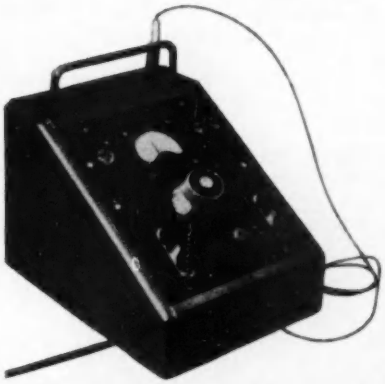


shown above is a specimen of the work done on this machine.

SERVOMEX
New Field Plotter FP92



This novel device can be applied to field problems in many branches of science and engineering; in fact, wherever the inverse square law applies. The interesting example above shows lines of electric equipotential in the insulation of a transformer. Observe that the electric stress has been magnified near the windings, because the equipotentials at these points have been plotted every 5% instead of every 10% as in most of the field. The price is £33, delivery from stock.

This field plot was supplied by the courtesy of the Transformer Development Department of Ferranti Limited, Hollinwood.

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NOW

DIRECT PHASE and AMPLITUDE MEASUREMENTS in POLAR (R,θ) and CARTESIAN (a,jb) CO-ORDINATES

with the World's Foremost Servo-Test Equipment

SOLARTRON

TRANSFER FUNCTION ANALYSER

(T.F.A.)

AND

REFERENCE RESOLVER (JX 746)

- *Signal in Polar (R, ⊖) and Cartesian (a, jb) Coordinates*
- *Frequency range 0.1 c/s — 1 kc/s (± 2% accuracy)*
- *Identification of vector quadrant*
- *High sensitivity (50 mV F.S.D.)*
- *Discrimination against noise and distortion*
- *Optional Log Amplitude/Phase indication for Nichols chart*

The Solartron T.F.A. and Reference Resolver JX 746 combination is unique in that it provides the required response of a system in a form suitable for the direct plotting of Nyquist and Bode diagrams.
The JX 746 extends even further the versatility of the already world famous Solartron T.F.A. and provides a digital display of phase angle.

The basic principles of this new technique in dynamic analysis are best explained by reference to the following experimental procedures.

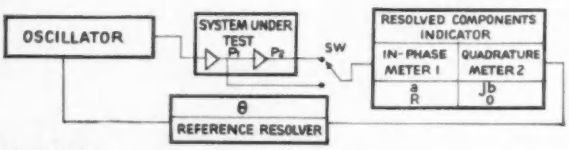
I To plot the Frequency Response of a given system over the range 0.1 c/s — 1 Kc/s in Nyquist and Bode form.

II To plot Amplitude and Phase Difference between two elements within the loop.

APPARATUS

1. Oscillator (OS 103.2)
2. Resolved Components Indicator (VP 253.2)
3. Reference Resolver (JX 746)

LAYOUT



METHOD

I Overall Frequency Response (at P_1)

1st step:

Feed system under test with accurate frequencies over 0.1 c/s to 1 kc/s (Oscillator OS 103.2)

2nd step:

Observe in-phase and quadrature components 'a' and 'jb' shown on Meters 1 and 2 of the Resolved Components Indicator VP 253.2. (see fig. 1)

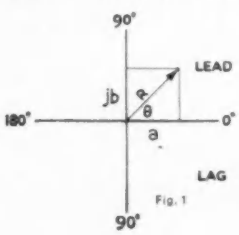


Fig. 1

3rd step:

By means of Reference Resolver (JX 746) rotate reference axes of the Resolved Components Indicator until the quadrature meter reading is zero. (see fig. 2).

4th step:

Note R = reading on Reference Meter 1 and ⊖ = digital reading on JX 746 Plot on Nyquist and Bode diagrams.

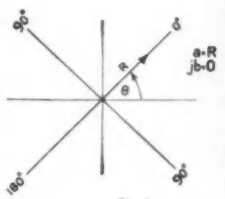
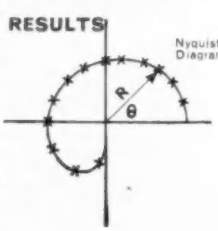


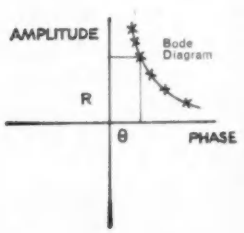
Fig. 2

II Amplitude and Phase Comparison between two points in the system (P_1 and P_2).

Having already resolved P_2 into R and ⊖ form, switch Resolved Components Indicator to P_1 and repeat the 3rd step.
Note differences in Amplitude and Phase on Reference Meter 1 and JX 746 respectively.

RESULTS

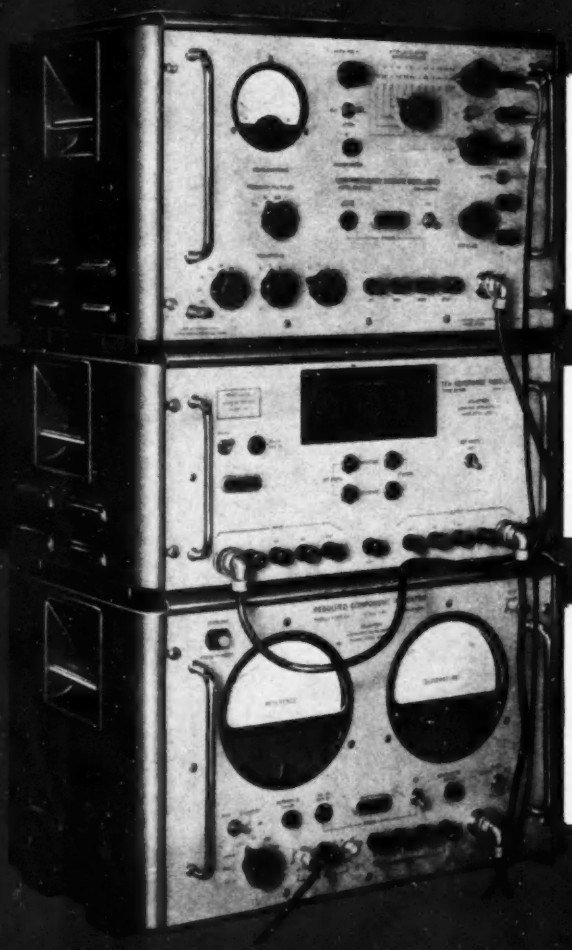




T. F. A.

The ease of operation and high measuring accuracy of Solartron T.F.A. and JX 746 are unsurpassed in the field of dynamic analysis. These are precision instruments for determining the behaviour of—
Electrical, Mechanical and Hydraulic Servo systems —Amplifiers — Networks — Self Regulating Systems—complete Servomechanisms and Regulators —Automatic Process Control Equipment—etc— under all operating conditions.

The Solartron T.F.A. comprises the L.F. Decade Oscillator (OS 103·2) and the Resolved Components Indicator (VP 253·2)



RESOLVED COMPONENTS INDICATOR VP 253.2

(Frequency coverage 0.5 c/s — 1 kc/s)

This is an L.F. Valve Voltmeter with two special 6" diameter meters indicating in-phase and quadrature components of the signal voltage with respect to a reference voltage of the same frequency.
Spurious noise and harmonics are cancelled out in the unique measuring method employed in this instrument. An amplifier overload indicator ensures that no false readings are taken on the meters, which are themselves protected against overload.

THE REFERENCE RESOLVER JX 746

(Frequency coverage DC — 1 kc/s)

Specially designed for use with the Solartron T.F.A., enables the transfer information to be expressed directly in terms of amplitude and phase. The phase angle is displayed by three digital indicators.

L.F. DECADE OSCILLATOR OS 103.2

(Frequency range 0.01 c/s — 11.1 kc/s to cover sub-audio and audio)

This oscillator, specially designed for T.F.A., generates low distortion sine-waves 4 phases — 0°, 90°, 180° and 270°.
A built-in meter gives an accurate level indication of the stabilised output down to the lowest frequency.
A precision attenuator enables the 10 V stabilised output to be accurately attenuated in 108 steps down to 10 mV.
A square-wave output is also available, covering the same frequency range and of continuously variable amplitude up to 17 V pk-pk.

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Special Works Memo

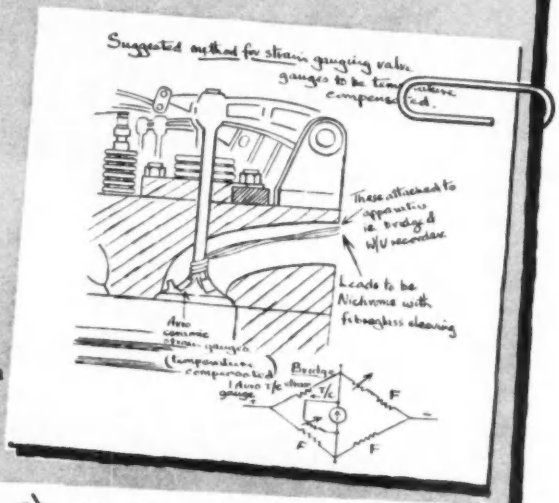
TO Production Engineering and Process Control Depts.

FROM Chief Engineer, Special Projects Division.

Tests have been carried out on two new Armstrong Whitworth Equipment products. Results have been excellent and these items might well be the answer to several of our problems. Preliminary details are:-

(1) Avro High Temperature Strain Gauges

Strain or minute structural variation measurable accurately at temperatures up to 1,000°C. Transverse resistance cross sensitivity negligible due to rectangular grid section design and stray thermo-electric effects nil. Ceramic cement impregnated non-removable fibrecloth backing bends around small radii. Fixing is by proven adhesives. Illustration shows typical hot point use for gauges. Note that temperature compensating thermo couples may be supplied built into each gauge!



(2) Limited Angle Tacho-Generator

Operates on a 30° angle about a mid position.
Size 1" rotor (2" nominal dia. case 3.75" long). There is also a 3" diameter rotor generator for special order.
Sensitivity 5 volts/radian/sec. ±15%
Load 27 kil-ohms
Frequency response 3 db down at 37 cycles/sec.
Winding resistance 1,680 ohms ±5%
Operating torque 500 gm. cm.
Direct lever drive eliminates gear back lash discrepancies.

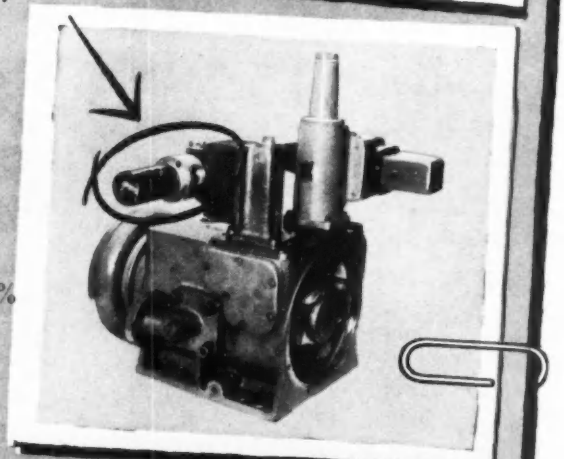
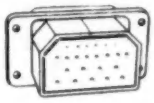
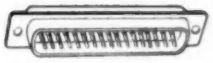
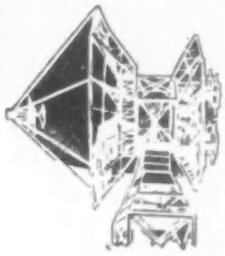


Illustration shows use for velocity feed-back measurement on swash-plate pump driving large machine tool.

ARMSTRONG WHITWORTH EQUIPMENT, Hucclecote, Gloucester. Telephone: Gloucester 66781
SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD., MEMBER OF HAWKER SIDDELEY AVIATION

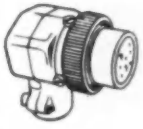


CANNON PLUGS

CANNON ELECTRIC (Great Britain) Ltd., announces that its shares formerly owned by the Forrester family, have now been purchased by CANNON ELECTRIC CO. (Los Angeles). The British firm will continue the full scope of present operations as a wholly owned subsidiary, with Mr. Forrester serving as consultant to the company.

Headquarters and sales offices of Cannon Electric (G.B.) Ltd. are being moved to the address below. As from February 6th all new correspondence enquiries and orders should be addressed there.

The manufacture of Cannon connectors will continue with undiminished volume at the company's London works in Bickerton Road. Other Cannon plugs will, as in the past, be imported from the parent company's plants in the U.S.A. and Canada. This combined engineering and production will continue to provide British customers with the broadest possible range of high quality electrical connectors.



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2S301	2S302	2S303
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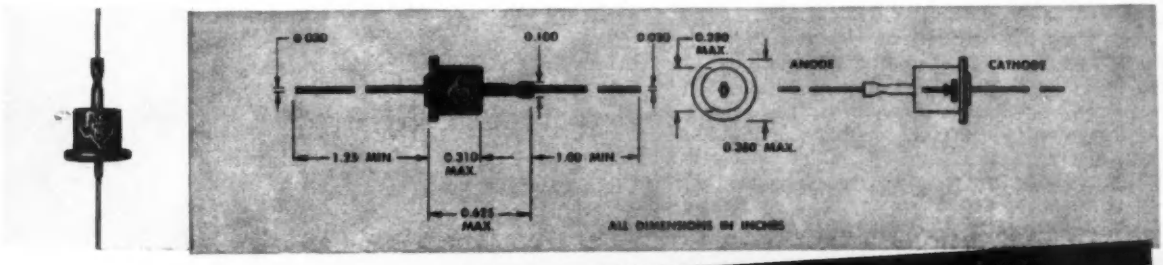
Recurrent Peak Forward Current at +25°C	... i_l	2·5	2·5	2·5	2·5	2·5	A
Surge Current, 1 cycle at 60 c/s at +25°C	... I_{pk}	15	15	15	15	15	A
Operating Temperature, Ambient	T_{amb}	——	——	−40 to +100	——	——	°C



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OC200
OC200
OC200
OC200

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*** now costs less than any other silicon alloy transistor**
*** now even cheaper than many germanium types**

SO NOW you can specify a quality silicon alloy transistor — in most of those instances where previously silicon semiconductors were considered too costly. What's more, there are no delivery problems. Thanks to Mullard large scale production, the OC200 is available for immediate delivery in quantity.
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Minimum operating ambient temperature	(°C)	− 50
Maximum junction temperature	(°C)	+ 150
Abridged data (at Tambient 25°C)		
V_{cb} max.	(V)	− 25
V_{ce} (cut-off) max.	(V)	− 25
V_{ce} (I_c=50mA) max.	(V)	− 20
I_c (pk) max.	(mA)	50
I_c max.	(mA)	50
α^1 (f=1kc/s) spread		15 to 60
V_{ce} (I_c=7mA, I_b=1mA)	(mV)	− 130
$r_{bb}{}^1$ (V_{ce}= −6V, I_c=1mA)	(Ω)	125

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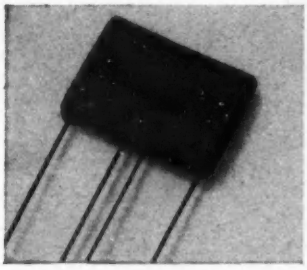

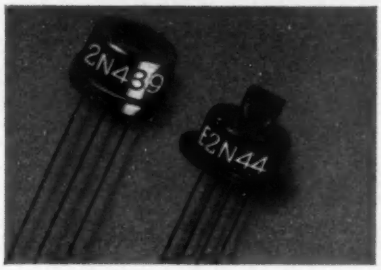

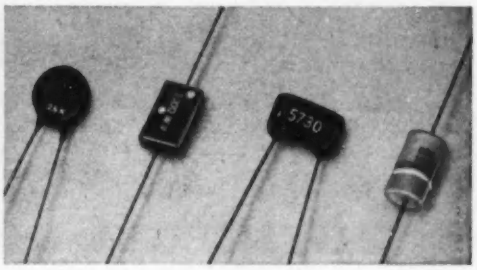

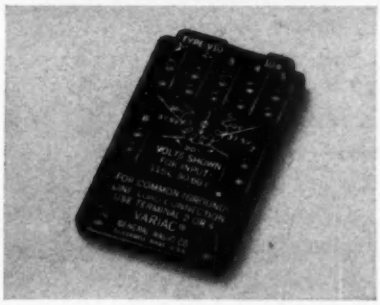

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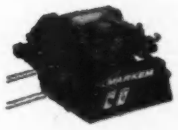
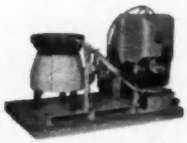
HERE'S HOW TYPICAL MARKING NEEDS ARE MET BY MARKEM

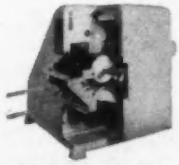


Model 146A — Marking Axial Lead Components with complete legends, including polarity band. Prints neatly on curved, uneven or irregular surfaces. Can be adjusted quickly to different sizes of components. Production speed up to 3000 per hour.



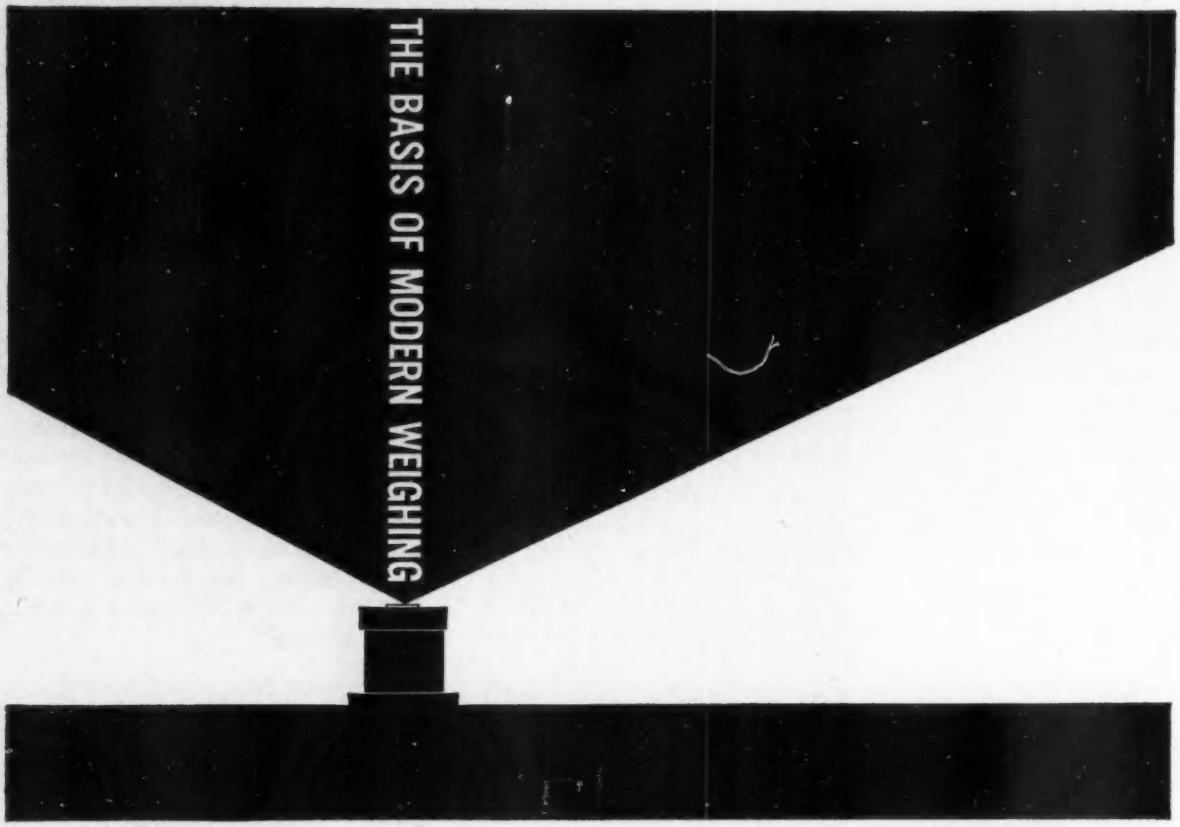
Model 122A — Simultaneous Top and Side Marking as well as date coding of transistors, similar cylindrical components with base leads. Hopper-fed machine automatically prints and ejects up to 3000 per hour.

Model 148A — Completely Automatic Marking of all types of surfaces — flat, curved, corrugated, irregular, etc. — without hand rolling or pressing. May be mounted for automatic in-line marking or objects may be hand fed to adjustable work table. Average production 2100 to 3100 per hour.



Model 69A — Color Banding of diodes, resistors, capacitors, similar axial lead cylindrical components up to 4800 per hour. Up to 6 colors simultaneously, or 5 color bands plus typographical marking. Color, band width, spacing easily changed.

Write for this 12-page catalog of Markem machines and related equipment for the electrical and electronics industries. Complete specification sheets are also available for individual machines.



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A superior weighing device of first class constructional design employing unbonded strain gauges, giving high zero stability and excellent overload features.

Associated equipment of equally high standard provides facilities for remote control, visual display of output or permanent records in the form of print, punched card or tape from any number of cells.

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- **Accuracy — better than 0.25% of f.s.d.**
- **High zero stability.**
- **High long term stability on load.**
- **Good overload facilities.**
- **Fail safe in event of gross overload.**
- **Oil filled and hermetically sealed.**
- **Corrosion resistant**
- **5 standard types to weigh up to 50,000 lbs.**

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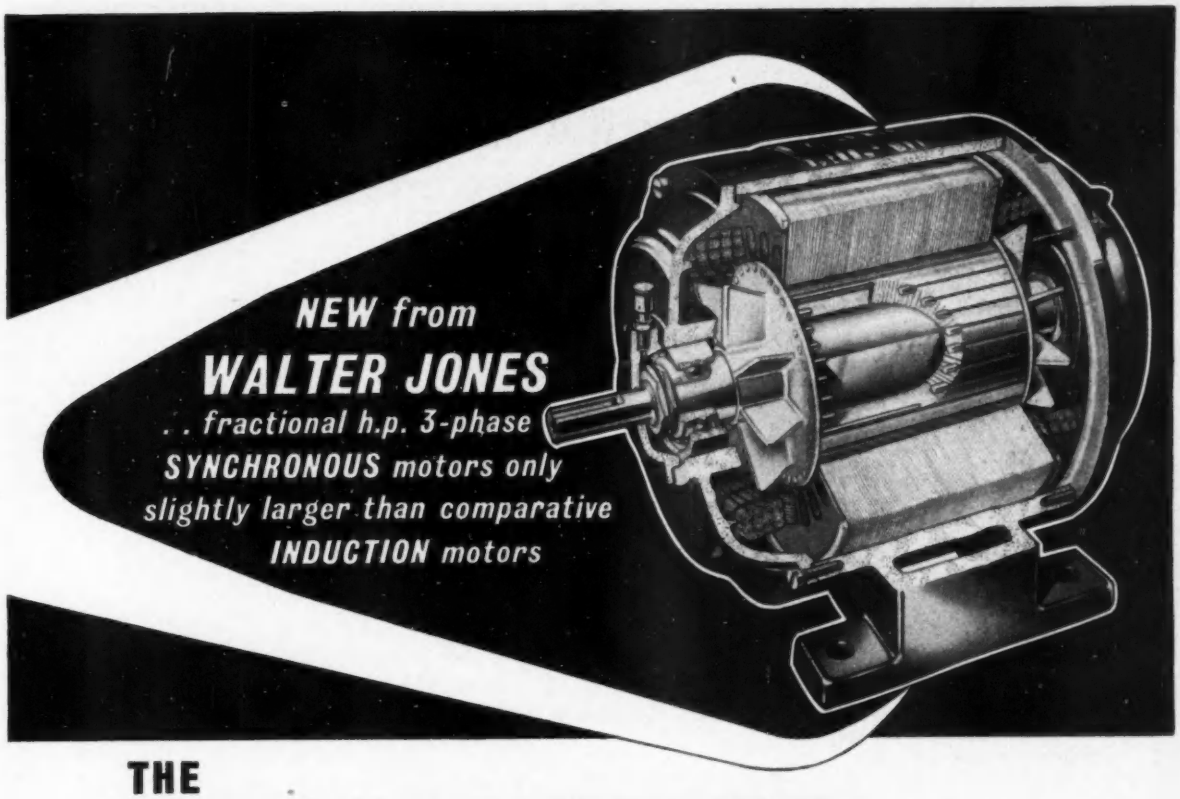

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3-PHASE SYNCHRONOUS MOTOR

Developed to meet the growing requirement for fractional horsepower, 3-phase, self starting and self-synchronising motors of compact size and enhanced performance, these machines have a higher synchronous output rating for their size than any similar machine of conventional permanent magnet or reluctance designs.

The rotor construction incorporates new technical features. It comprises a central permanently magnetised core around which are assembled annular laminations and copper conductors to form the familiar squirrel cage.

The core utilises a modern high remanence alloy and the improved technical advances of the rotor minimise the de-magnetising effects on starting and synchronising.

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Frame size		012	017	N15	N22	M20	M30	L25	L39
50 c.p.s. 2-pole 3000 RPM	HP	·04	·06	·10	·16	·22	·38	·46	·75
50 c.p.s. 4-pole 1500 RPM	HP	·025	·033	·07	·10	·15	·22	·33	·50
400 c.p.s. 4-pole 12,000 RPM	HP	·20	·28	·50	·75				

Manufacturers for over 40 years of small power Electrical rotating equipment.

SEND FOR SPECIFICATION LEAFLETS OF THIS AND OTHER PRODUCTS

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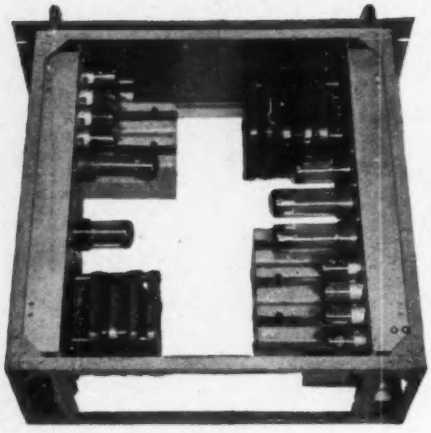
regulated - well ventilated - power supplies



Improved Brandenburg design, with wide centre ventilation and easier access to all components. Two of model V300/200 mounted in one suitable frame measuring 17½″×17½″×7″. This shows one of many methods of mounting these units.

All models—types V and HV, voltage stabilized.

polarity reversible
effective resistance 0·1 ohm
stability against + or − 10% mains change: 0·02%
ripple less than 1mV
input 200/250 volts, 50 cycles.
output a.c. 100 and 200 mA models: 4×6·3V, 1·5A. 350 and 500 mA models: 2×6·3V, 5A. All can be paralleled
dimensions 100 and 200 mA models: 15¾″×5¾″×6¾″ high. 350 mA models: 15¾″×7½″×7½″ high. 500 mA models: two chassis, each 15¾″×5¾″×6¾″ high. Flanged open chassis, with frames available for converting all models to front panel mounting

All prices quoted are for U.K. only—ex-works

200-350 V.		150-350 V.	
100 m/A.	£37 10 0	1 A.	£140 0 0
200 m/A.	£48 10 0	2 A.	£230 0 0
350 m/A.	£64 0 0	2 A. model complete with 19″ front panel and assembly	
500 m/A.	£80 0 0		

new current-stabilized models

type C300

input 200/250 volts, 50 cycles
output current 50-300 m/A, continuously variable
output voltage 5000 volts, maximum
stability better than 0·1% for + or − 7% mains variation
drift less than 0·5% for 30 minutes

enquiries are invited for similar specifications

Brochure of Brandenburg voltage-stabilized range also available

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BRANDENBURG LIMITED

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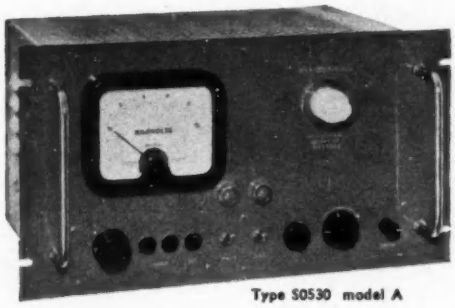
Export enquiries to: Applied Research (Instruments) Ltd. Emefco House, Reigate, Surrey, England

high voltage regulated power supplies —standard models up to 100 kV.

5, 10, 20 and 30 kilovolt regulated supply



Type S0530 model A

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Type S0530

output	1 to 10 kV at 2mA. Model A 2 to 20 kV at 1 mA. Model B 3 to 30 kV at ½ mA. Model C 500 V to 5 kV at 2 mA. Model D
input	200/250 volts, 50 cycles
polarity	positive or negative grounded available
regulation	against full load: better than 0.5%. Against mains variations of plus or minus 7%, better than 1%

- 5" Ernest Turner movement
- current metering jack
- standard 19" x 10½" P.O. panel
- for rack mounting or bench use

£135 *ex-works*

Models A, B and C can be supplied with reversible output polarity at £165

50 kilovolt regulated supply

Type MR50R

Type MR50R

output	5 kV to 50 kV at 1 mA
input	200/250 volts
polarity	reversible
regulation	against full load: better than 1% Against mains variations: +5%,—5%, better than 1%
dimensions	W: 24" H:23" D: 15"

£245 *ex-works*

100 kilovolt regulated power supply

Type MR100R—3 models

output current	0.5 mA. Model MR100R/500 1 mA. Model MR100R/1
output voltage	10 to 100 kilovolts, continuously variable
polarity	reversible
ripple	0.1%
regulation	no load to full load: better than 1%. Against mains variations of plus or minus 7%, better than 1%
input	200/250 volts, 50 cycles
metering	output voltage and current metered by 5" Ernest Turner, Model 605

Brochure on request : for further specifications of this Brandenburg range of standard high voltage equipment, please write for brochure.

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For the removal of oxygen from other gases

DEOXO CATALYTIC GAS PURIFICATION PROCESS

The model 'D' Deoxo Purifier, which operates at room temperature, provides for the removal of oxygen or hydrogen from other gases such as argon, helium nitrogen, etc., with a remaining impurity of less than 1 ppm. These Purifiers are available in a number of standard sizes for gas flows from 5 scfh to 10,000 scfh.

Additional units are available for the removal of other impurities from a wide range of industrial gases.

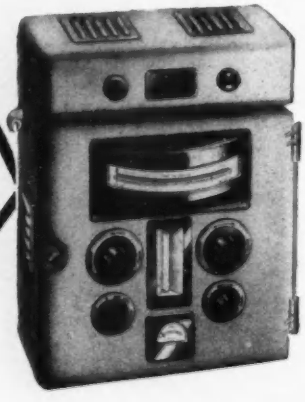
For pure dry hydrogen

DEOXO PURIDRYER

The Deoxo Puridryer will remove oxygen from hydrogen to leave less than 1 ppm of the impurity remaining, and subsequently dry the purified gas to a dew point as low as minus 100° F, at flow rates of up to 100 scfh.

Provision for regenerating the drying agent is incorporated in the unit.

For continuous measurement of oxygen



HERSCH OXYGEN METER

The Hersch Oxygen Meter has been designed for the measurement of trace oxygen in other gases in the range 0-10 and 0-100 ppm. The high sensitivity, accuracy and speed of response enables this instrument to be used both for laboratory investigation and production quality control.

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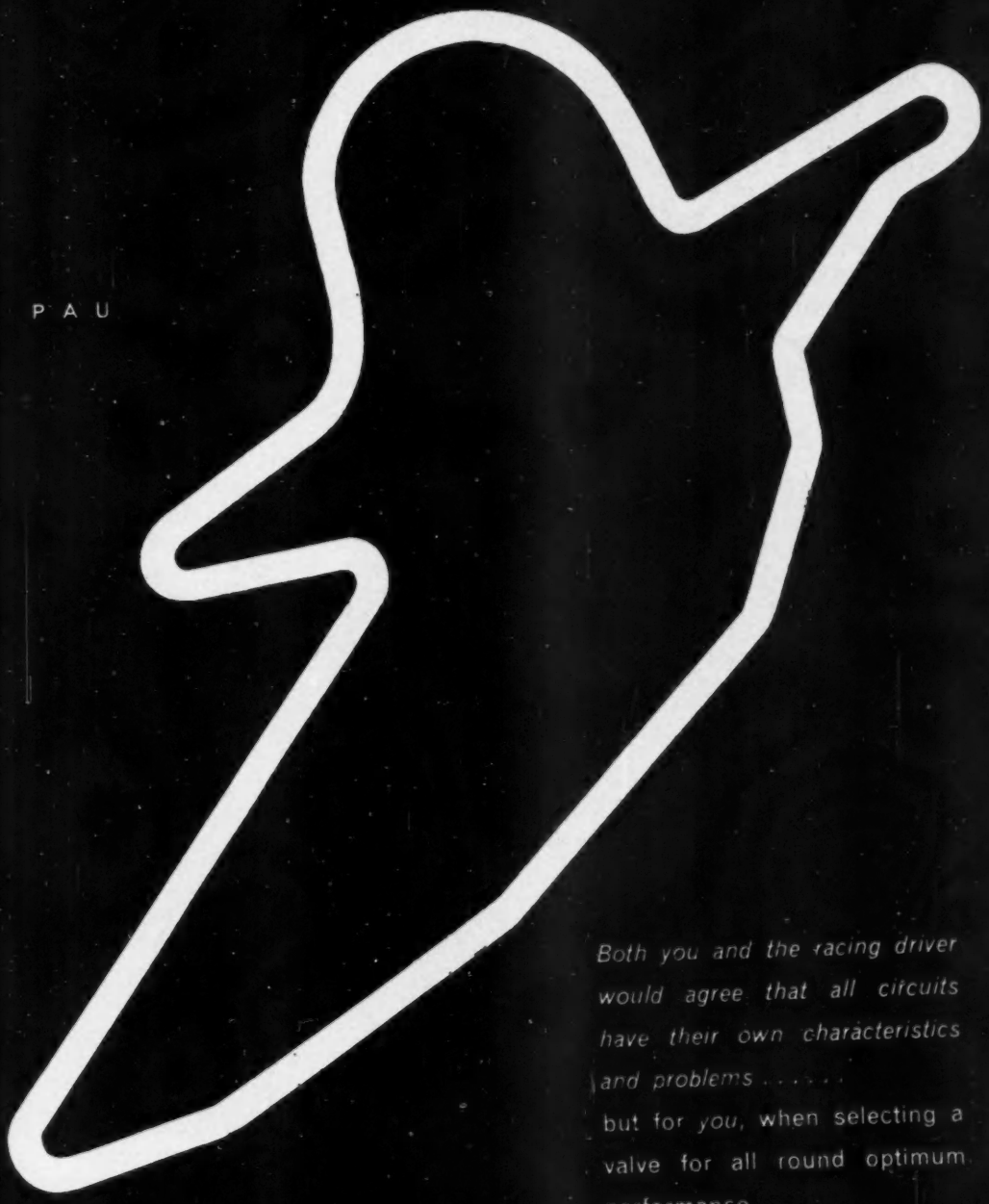

Both you and the racing driver would agree that all circuits have their own characteristics and problems . . . . . .

but for *you*, when selecting a valve for all round optimum performance . . . . . .

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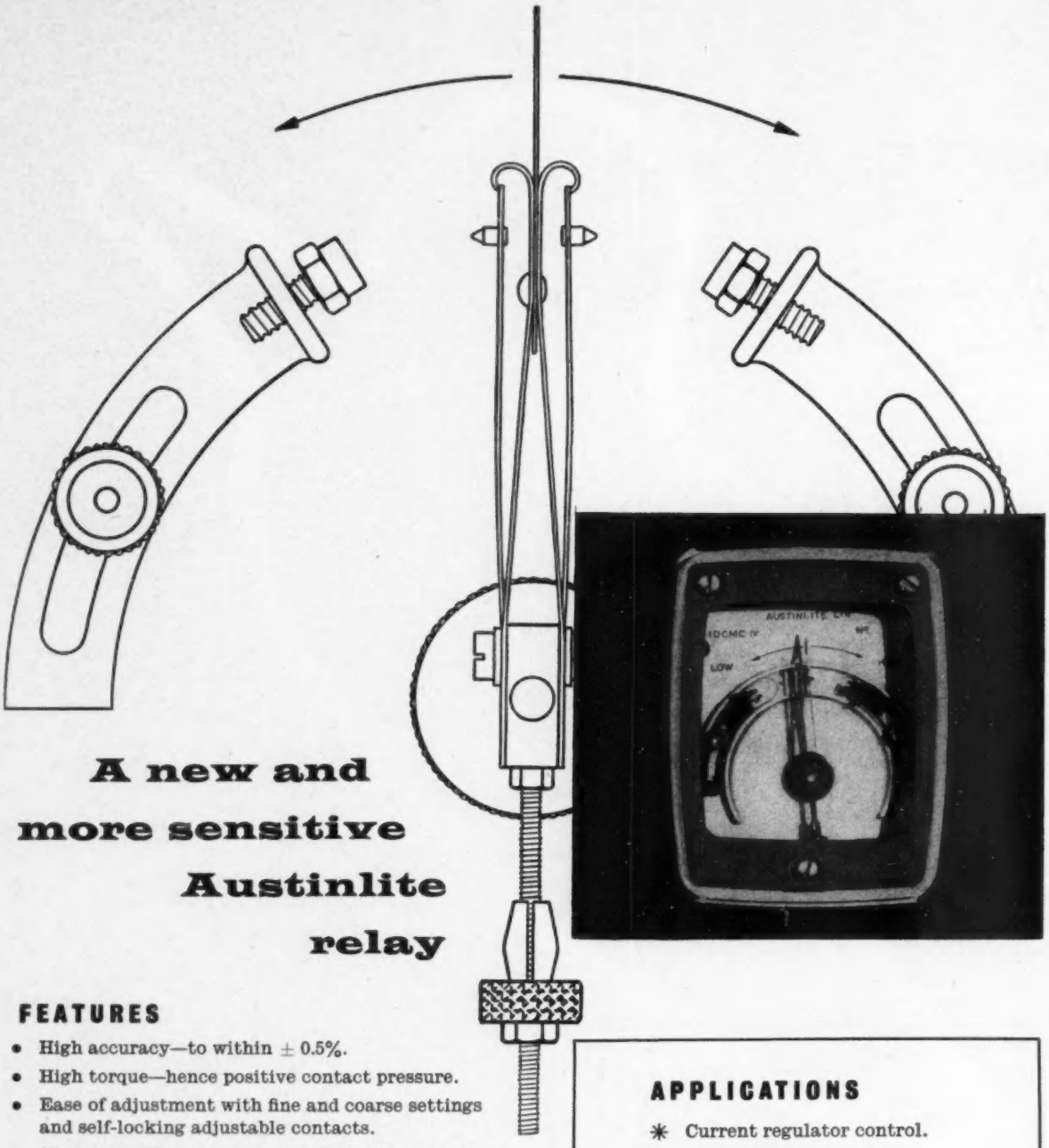

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- Choice of either two or four adjustable contacts.
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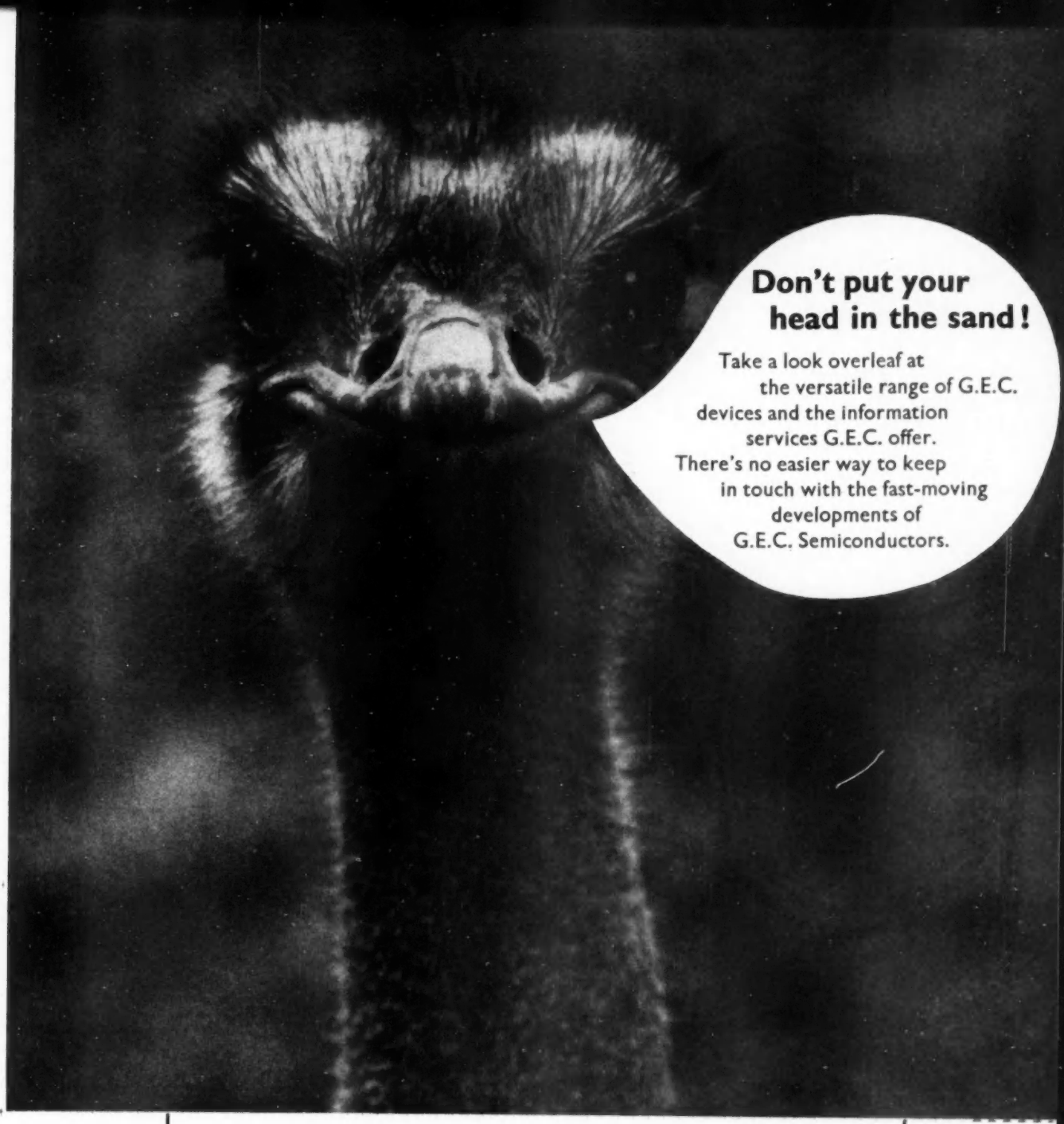
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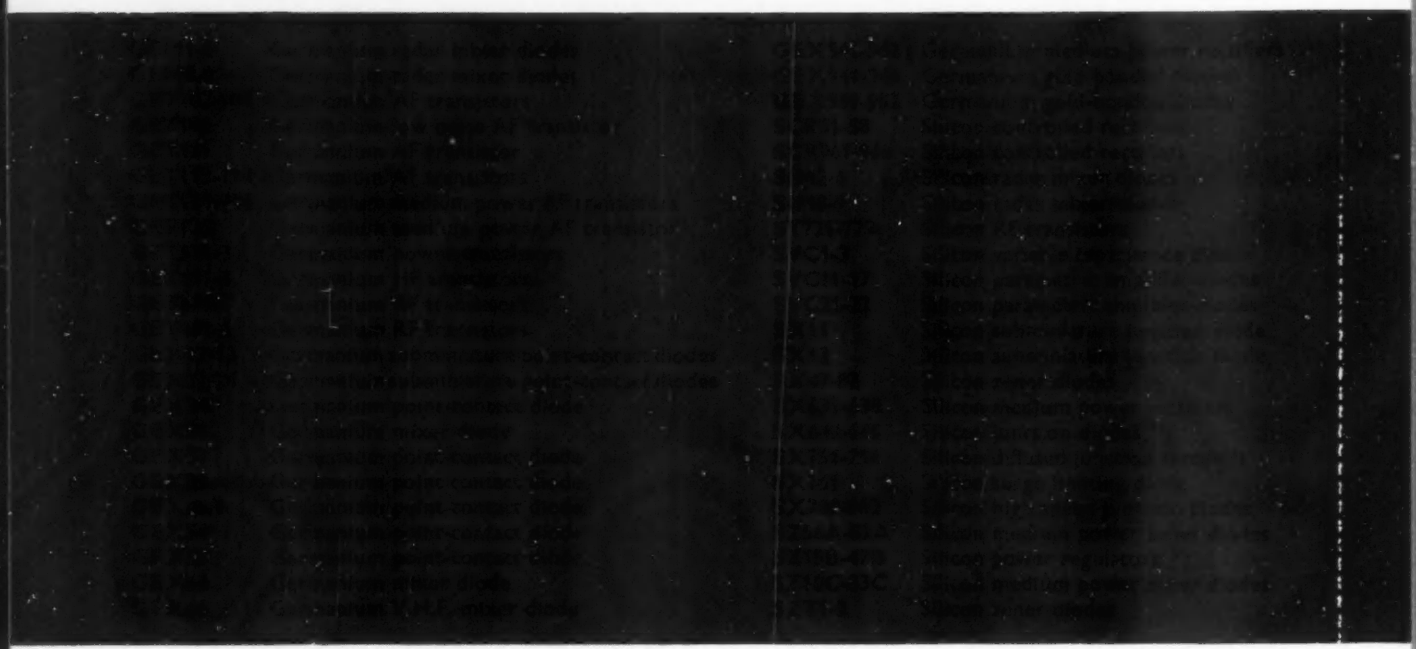

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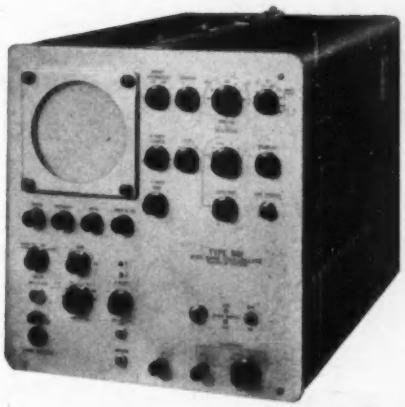

TWO CHANNEL
with plug-in pre-amps
providing various input
conditions accurately calibrated

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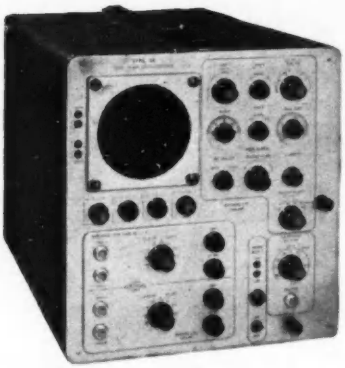
High Speed
D.C.—40 Mc/s
Single Beam



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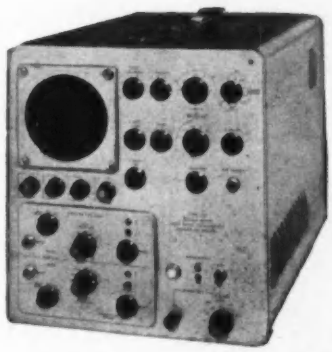

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D.C. to 20 Mc/s—
10 KV High writing speed,
with range of plug-ins
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essential and reliable electronic test gear

5101 TYPE
Square wave and pulse group generator—
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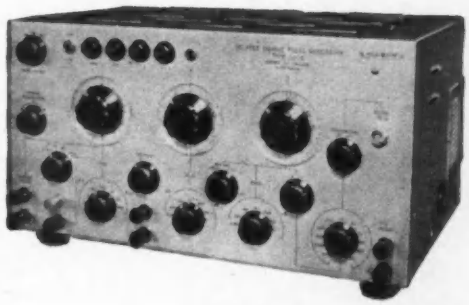

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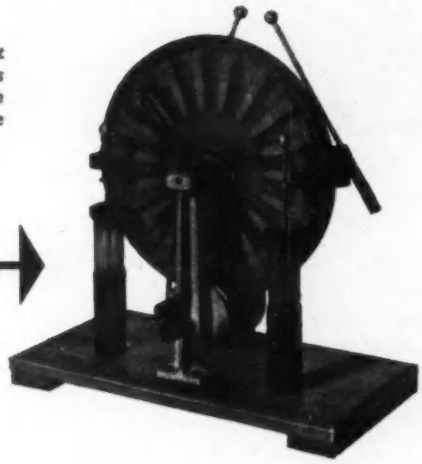
During the years 1878-1888 Mr. James Wimshurst contributed considerably to the science of physics by designing and constructing a number of High Voltage Generators of the type shown in the illustration.



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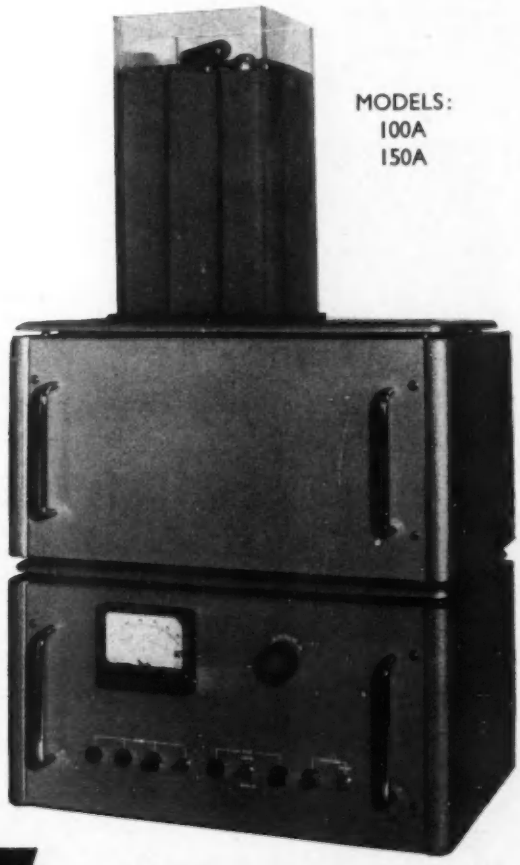

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POWER SUPPLY UNITS

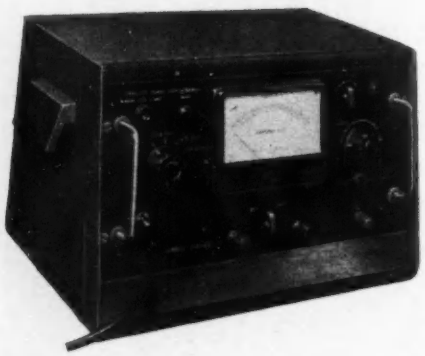
Transistorised Voltage Regulated

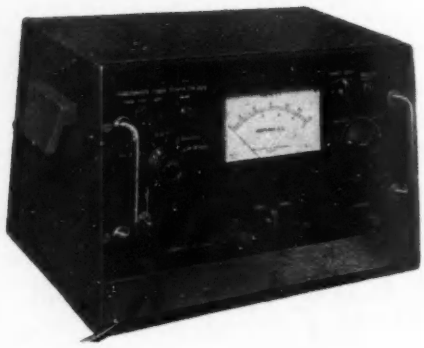
Transistorised Power Supply Unit

Type **TSV 30/2EC**

with variable electronic cut-out operating over full current range.

Input Voltage:	110-220 volts with taps 5, 10, 20 volts on both ranges. 40/60 c/s.
D.C. Output:	0-30 volts D.C. variable over complete range.
Maximum Output Current:	2 amps continuous.
Case Dimensions:	14½" long × 10½" deep × 10" high (with feet).





Transistorised Power Supply Unit

Type **TSV 30/5EC**

with variable electronic cut-out operating over full current range.

Input Voltage:	110-220 volts with taps 5, 10, 20 volts on both ranges. 40-60 c/s.
D.C. Output:	0-30 volts D.C. and continuously variable.
Maximum Output Current:	5 amps continuous.
Case Dimensions:	14½" long × 10½" deep × 10" high (with feet).

NOTABLE FOR High Stabilization, Low output impedance, Low Ripple and Noise content, overload protection fuses fitted to all models and electronic cut-outs with variable current control fitted to TSV.30/2 and 30/5 models. Fully transistorised, Zener Diode References, Output—positive or negative to Chassis, Early Delivery on all Models, write for illustrated leaflets for further details.

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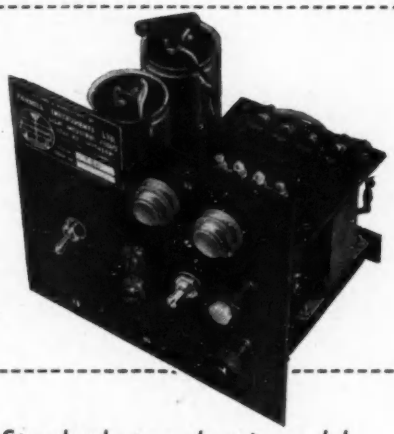


Inexpensive open chassis model

Transistorised Power Supply Unit

Type **TBO**

Input Voltage: 0-200/250 volts A.C. 50-60 c/s.
D.C. Output: 6-12 volts D.C. pre-set.
Output Current: 1 amp maximum.
Dimensions: 6" long × 6" deep × 5" high.

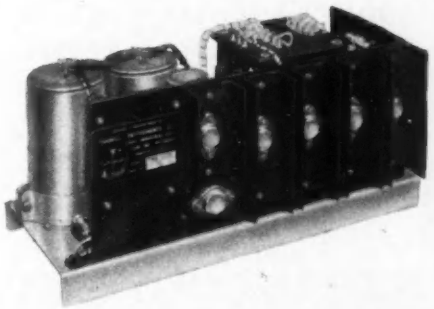
Standard open chassis model

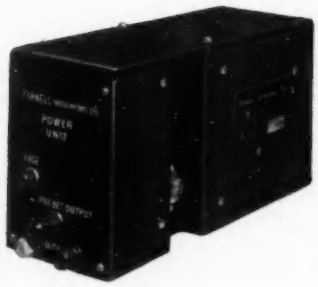
Transistorised Power Supply Unit

Type **TSO 30/5**

Input Voltage: 110-220 volts A.C. 50 cycles.
Maximum Output Current: 5 amps continuous at 18-30 volts.

Also available TSO 18/2, (0-18v at 2a) TSO 12/5 (0-12v at 5a) TSO 30/2 (18-30v at 2a).





De-luxe open chassis model

Transistorised Power Supply Unit

Type **SSU**

10 models are available covering ranges 0-65 volts, with D.C. outputs: 1 or 2 amps. Write for details.

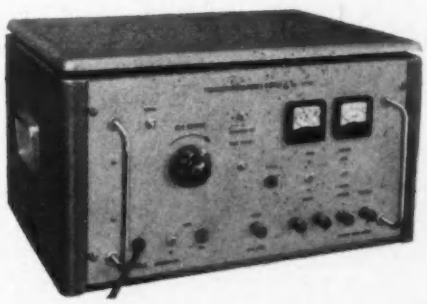
Model A, dimensions 4½" × 10⅜" × 6¼" high, covering range of 1 amp models up to 36 volts, and 2 amp models up to 18 volts.

Model B, dimensions 4½" × 10⅜" × 6¼" high, covering all other S.S.U. models not listed under Model A.

Transistorised Power Supply Unit

Type **TSV 50/5**

Input Voltage: 0-230/250 volts A.C. 50-60 c/s.
D.C. Output: 3-50 volts D.C. and continuously variable.
Output Current: 5 amps continuous.
Dimensions: 21½" long × 16" deep × 12" high.



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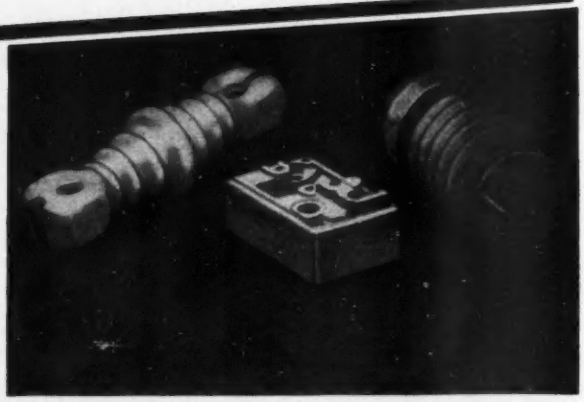

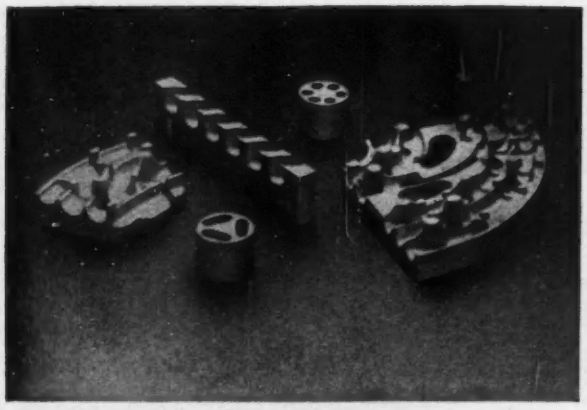

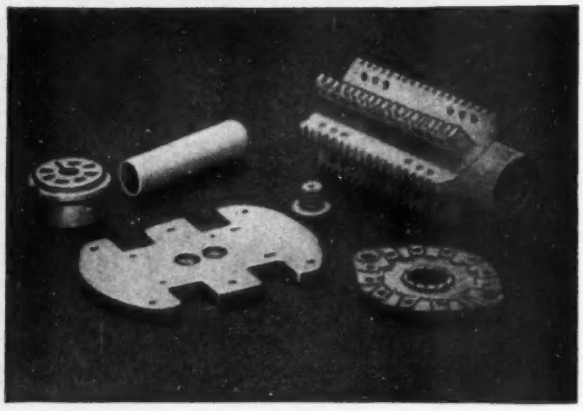

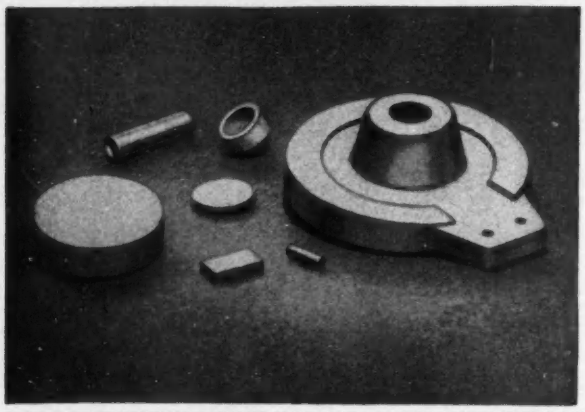

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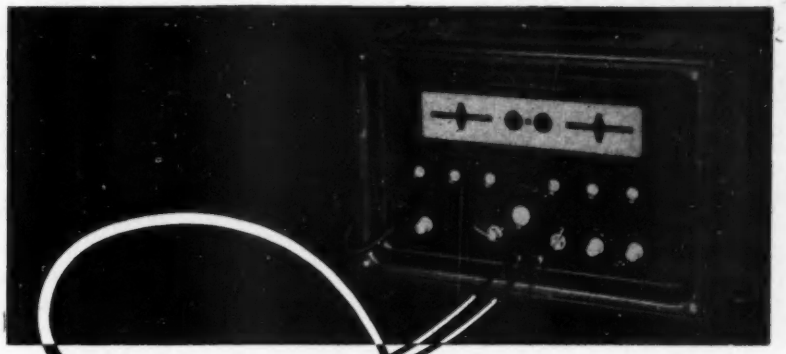

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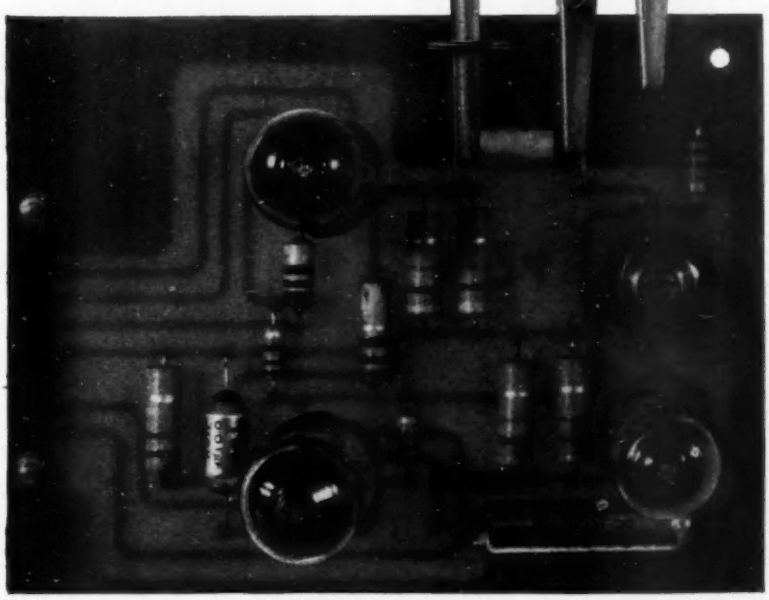
as long as you like

Accurate, remote measurement extends dramatically the application of bridge techniques.

Measurement of the individual components of complex impedances to an accuracy of ±0.25%, without removing them from circuit, coupled with facilities for two, three and four terminal measurement, enable the Universal Bridge B.221 to be put to an almost limitless range of general industrial use.

The instrument will establish the characteristics of components and of circuits—further, special adaptors are available to cover the measurement of liquid conductivity, dielectric constants of solids and liquids, dry joints, switch contact resistance, circuit strays, boundary layer impedance of liquids, permittivity and loss factor of solids and liquids—and dielectric properties of liquids in test tubes.



Foolproof, direct reading dials

The Universal Bridge B.221 has as a special design feature the layout of the controls and displays. A novel mechanism automatically inserts the cyphers, decimals and units of measurement in the dial windows. Thus, the errors which may be caused by large multiplying factors are obviated. This facility means that the instrument may be used efficiently even by unskilled personnel.

This instrument and its applications are fully discussed in Information Service Publication AB221—copies available on request.

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Universal Bridge B221

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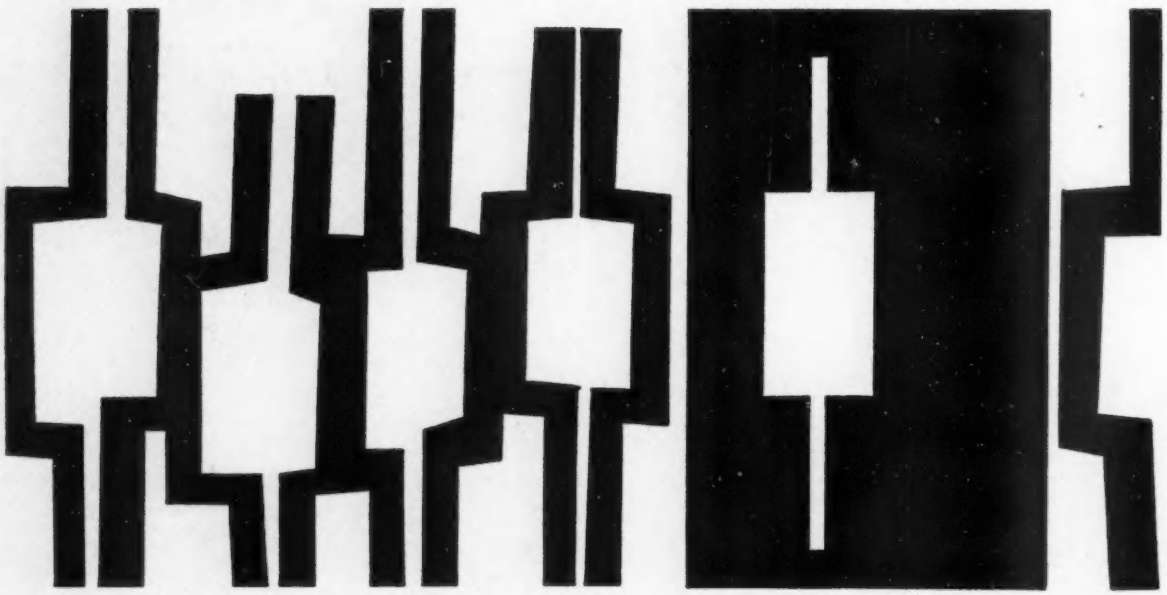
e.r.f. inductors *withstand vibration, temperature extremes*



For further information, specifications etc., on Plessey E.R.F. inductors contact:

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ELECTRONIC ENGINEERING

VOL. 33 No. 398

APRIL 1961

Commentary

FROM all angles the annual review for 1960 which has recently been published by the Electronic Engineering Association is a highly satisfactory document, reflecting the enterprise and efficiency of a section of British industry which continues to increase its output each year by some ten per cent and produced equipment last year to the value of about £500M.

In what is referred to as the capital goods side of the industry—the section which is the concern of the Electronic Engineering Association—the figures are no less satisfactory, for its member firms produced equipment during the period under review to the value of £175M of which some £28M worth was exported, often in the face of severe foreign competition—competition which, according to the Electronic Engineering Association, has not always been strictly economic.

In the field of air navigational aids one of the major technical achievements of the year has been the completion of the development of the Autoland system, a result of the close collaboration of the Blind Landing Experimental Unit of the Ministry of Aviation and four member companies of the Association.

This is the system which will enable an aircraft to be brought to a runway and landed without the intervention of the pilot. It has already completed many thousand successful landings and is now being evaluated for its military application. In addition it is being very closely studied by the civil air lines of the world for it promises in one clean sweep to remove one of the most dangerous hazards of the day, namely the landing of aircraft when visibility is poor or non-existent.

Communication channels, says the review, are the nerve fibres of civilization and one of the most ambitious schemes ever proposed for communication must be the plan to link the members of the Commonwealth in a world encircling telephone cable.

The British electronic industry has been occupied during the past year with the manufacture of cables and submerged repeater equipment for this Round the World Commonwealth Cable and last month saw the departure of the Post Office cable ship 'Monarch' to lay CANTAT, the first section between this country and Canada.

Orders to the value of £20M have been placed for further cables and submerged electronic equipment for COMPAC, the Commonwealth Pacific cable which will run for some 8 000 miles across the Pacific Ocean from Sydney, Australia, to Vancouver, Canada.

This Round the World Telephone Cable vast though it is, is not the only communication scheme with which the electronic industry is concerned. On a smaller scale there has been the installation of an extensive inter-island and aeronautical system in the Caribbean which is stated to be one of the world's most advanced networks of its kind.

In broadcasting and television the review brings out the fact that we are now the world's leading exporters of transmitters, camera, studio equipment and outside-broadcasting units. Among the noteworthy installations within the Commonwealth are the sound and vision transmitters for New Zealand, Canada and Australia and mention must be made of the sound broadcasting installations at Hong Kong and Ghana; the latter will be the most modern high power short wave broadcasting system in the Continent of Africa. No less encouraging is the fact that some two hundred television cameras of British design and manufacture have been supplied to the television authorities of the world.

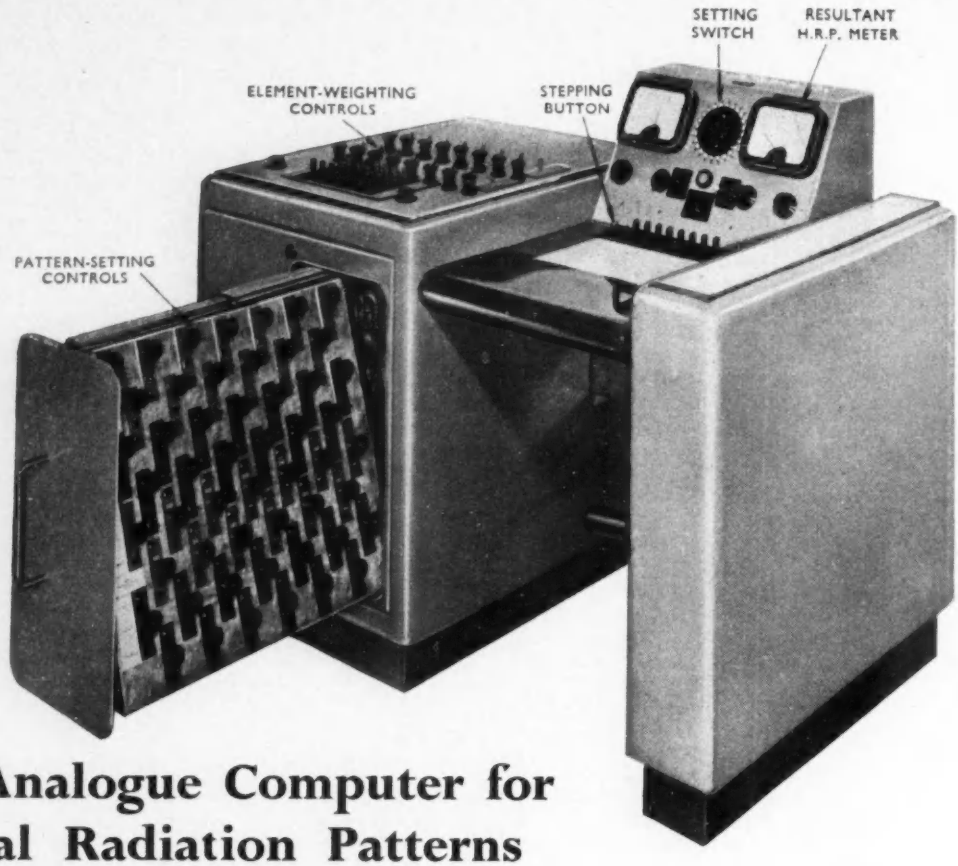
The industry has also been able to report a successful year both in the application of electronics to industry and in instrumentation.

The application of electronic techniques to machine tool control has now proved itself to be a practical proposition and by association with the machine tool makers several electronic firms have evolved highly elegant systems of machine tool control with the result that direct approaches have been made from a number of American machine tool makers who acknowledge the superiority of the British systems.

The Electronic Engineering Association review refers in glowing terms to the 'electronic's lusty youngster'—the data processing section which judging from its export activities alone has every reason to be satisfied with its achievements during the past year. It has sold computers to America and Japan and at an exhibition in Moscow a computer was sold within the first hour of the exhibition's opening, and a contract for ten more is now under discussion.

On the home market too, interest in computers is awakening. Banking Houses are now preparing plans to install full data-processing equipment for such routine tasks are cheque reading and sorting, and the oil and chemical industries are using the computer to control their complex manufacturing processes.

All in all it has been a most successful year and if at first reading the annual review appears a boastful document it can back up its claims with a very full order book; and the prospects for the present year are no less bright.



An Analogue Computer for Aerial Radiation Patterns

By H. Page*, M.Sc., M.I.E.E., G. J. Phillips*, M.A., Ph.D., B.Sc., A.M.I.E.E., and J. A. S. Fox*, B.Sc.

An analogue computer has been constructed to calculate the horizontal radiation patterns of aerial arrays comprising a number of radiating elements, mounted on a central support mast. The radiation pattern of a single element must be known, and from this the pattern for a number of identical elements round the mast may be calculated. The currents in the elements may have any desired amplitudes and phases.

The principle used is the addition of a number of audio-frequency voltages, each component representing the radiation from one element in a particular direction. By using a bank of rotary switches, the appropriate summations are made in turn for bearings at intervals which may be either 7·5° or 15°, the resultant being indicated on a meter. The computer may be adapted to other types of visual display.

(Voir page 264 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 271)

IN designing an aerial for television or sound broadcasting in the v.h.f. band it is frequently necessary to achieve a horizontal radiation pattern (h.r.p.) of a prescribed shape. It may, for instance, be desirable to radiate a high power in certain directions in order to serve selected highly-populated districts, and to restrict the power in other directions in order to minimize interference with stations working on the same channel.

In the preliminary planning stages it is the practice in the BBC to prepare a templet relating to the proposed station; this templet takes the form of two field-strength polar diagrams which show the minimum desired and the maximum permitted values of effective radiated power (e.r.p.) in all horizontal directions. The shape of the h.r.p. of the aerial should lie between these two closed curves, and the required transmitter power can be calculated knowing the e.r.p. and the gain of the aerial.

With the spread of television and v.h.f. sound broadcasting the number of common-channel stations has steadily increased and, as a result, the requirements for individual stations have tended to become more exacting. In some cases a satisfactory pattern may be obtained by using the mast as an aperiodic reflector (with or without additional reflecting members) in association with a single radiating element. A more flexible method is to use in each tier of the aerial a number of radiating elements, the relative amplitude and phase of the currents in these elements being chosen to give the required shape of h.r.p. in the presence of the mast.

The h.r.p. of one element mounted on a supporting structure can in some cases be calculated; in any case it

* *British Broadcasting Corporation.*

can be measured, for instance, by using a small-scale model. To derive the radiation pattern when a number of similar elements are used it is necessary to calculate the vector sum of their individual patterns. If the required pattern is complicated in shape, the field must be determined for a large number of directions; furthermore, in the search for the simplest system meeting the requirements, it may be necessary to explore many combinations of the number and position of the elements, and of the

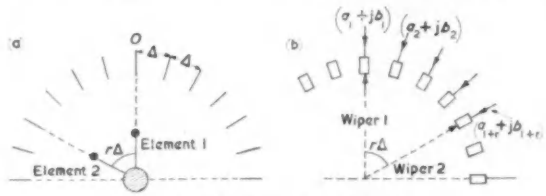


Fig. 1. The addition of radiation patterns

relative amplitudes and phases of the currents they carry. This process can be very laborious and time consuming, whether by hand computation or by the assembly and adjustment of a large number of experimental models.

The computer described here was constructed to ease some of the difficulties mentioned above. It is designed to perform the task of calculating from the radiation pattern of a single element, the radiation pattern for a number of identical elements; these may carry currents of any amplitude and phase, and may be disposed in different directions relative to the axis of the supporting structure, provided the spacing from the axis is the same.

The computer may also be used as explained later for calculations involving two types of elements, for instance, elements having different spacings from the axis; however, to simplify the description it is assumed initially that the elements are identical and equally spaced from the axis.

Principle of Operation

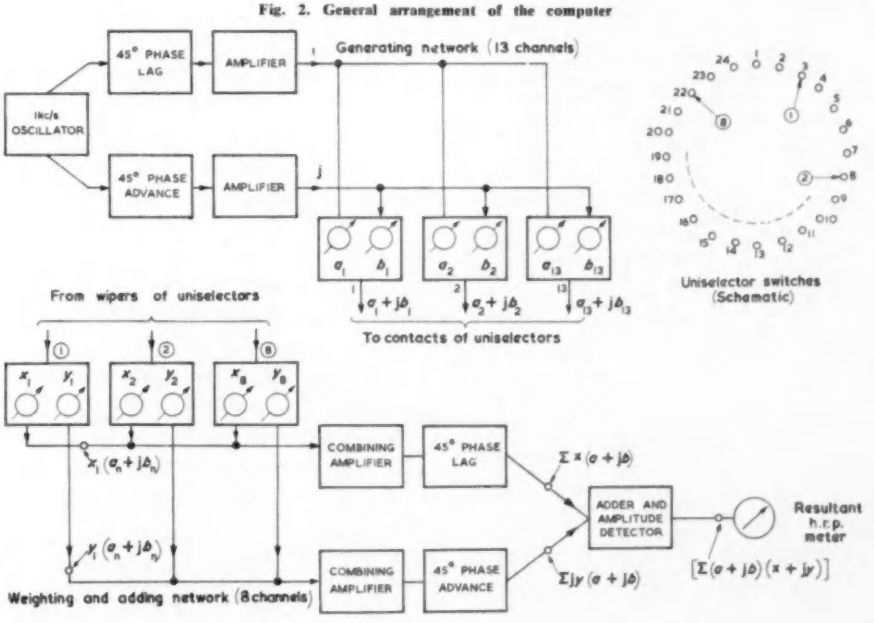
Consider the plan view of an aerial system consisting of a number of similar elements disposed round a support mast, as shown in Fig. 1(a). The radiation from one element is known for a number of equally spaced directions at angles 0, Δ . . . $n\Delta$ . . . (clockwise from the position of the element) in the form of a series of complex numbers $(a_1 + jb_1)$, $(a_2 + jb_2)$ . . . $(a_{1+n} + jb_{1+n})$ . . . respectively; the modulus of the complex number is the relative amplitude of the radiated field, and the argument is the relative phase referred to the axis of the mast. Suppose there are two elements as shown in Fig. 1(a) with element 2 at an angle $r\Delta$ *anti-clockwise* from element 1, where r is an integer. In this case the resultant in direction 0, for elements fed with equal in-phase currents, is the sum of $(a_1 + jb_1)$ from element 1 and $(a_{1+r} + jb_{1+r})$ from element 2; for the direction $n\Delta$ clockwise from 0 it is the sum of $(a_{1+n} + jb_{1+n})$ and $(a_{1+n+r} + jb_{1+n+r})$.

Summations of this kind may be achieved by a rotary switch, as indicated in Fig. 1(b). Alternating potentials of amplitudes $(a_1 + jb_1)$, $(a_2 + jb_2)$ . . . are applied to the contacts taken in sequence, and two wipers are used with wiper 2 staggered by r contacts *clockwise* relative to wiper 1. A summation of the wiper potentials for the positions shown in the diagram yields the resultant radiation for direction 0. By moving both wipers one step clockwise the resultant for the direction Δ clockwise from direction 0 is obtained; this process may be repeated to obtain the complete pattern at angular intervals of Δ. Moreover, if the aerial elements are fed with currents $(x_1 + jy_1)$ and $(x_2 + jy_2)$ respectively, the required resultant for direction 0, $(a_1 + jb_1)(x_1 + jy_1) + (a_{1+r} + jb_{1+r})(x_2 + jy_2)$, is obtained if the wiper potentials are multiplied by the factors $(x_1 + jy_1)$ and $(x_2 + jy_2)$ respectively, before summing.

In the computer described this principle has been extended to provide for any number of elements up to a maximum of eight, the unit angle (Δ) being 15°. A group of telephone uniselector switches is used, one for each radiating element; the corresponding contacts are electrically paralleled and the wipers are staggered, by electromechanical control, in a pattern which forms the mirror image of the disposition of the radiating elements.

A block schematic of the computer is shown in Fig. 2. The source used is a 1kc/s oscillator, each of the complex potentials $(a + jb)$ being obtained by combining two quadrature components of appropriate amplitudes. The multiplication by $(x + jy)$ is achieved by deriving fractions x and y of the output from a particular wiper; all the x and all the y components derived from the various wipers are added separately. The resultant y component is then advanced in phase by 90° relative to the resultant x component, and the two added. Since only the modulus of the resultant is required, a simple meter responding to the alternating potential can be used as the indicator; this displays $|\Sigma(a + jb)(x + jy)|$ for a given direction, the summation covering the total number of elements in the array.

Fig. 2. General arrangement of the computer



In operation, the values of a and b for each direction are first set up on the computer, the wiper orientations are adjusted according to the relative dispositions of the elements, and the weighting parameters x, y are set up to correspond to the relative currents in the elements. The resultant radiation is then indicated on the meter, the wipers being moved one step at a time by operating a press-button, so that a reading is obtained for each direction in turn; this operation will be referred to as 'stepping'.

The accuracy of indication of any radiation pattern is generally within 2 per cent of the maximum; this limit of accuracy is set mainly by inequalities of nominally identical components, but slight variations of the 'pattern' voltages with changes in the load presented by the switch circuits also contribute to the errors.

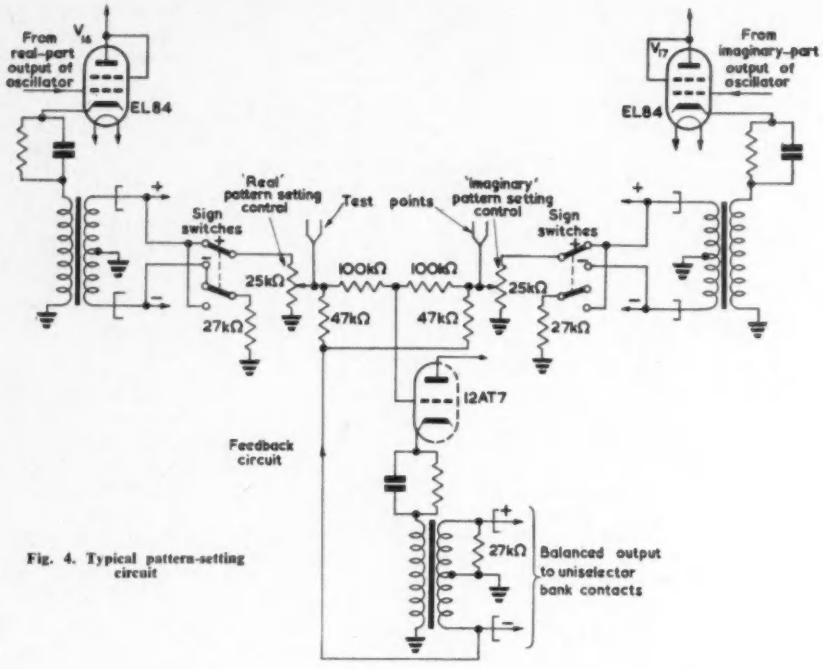


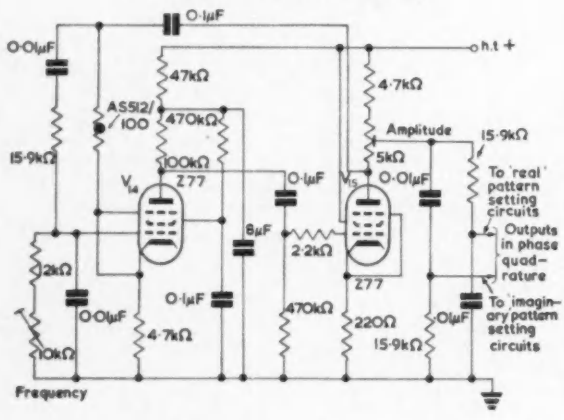
Fig. 4. Typical pattern-setting circuit

The switching process could of course also be done electronically; the electromechanical system was decided on because it did not entail any development and the equipment was urgently required.

Circuit Description

A photograph of the equipment is shown on page 206. The pattern-setting controls, which are set up to correspond to the parameters $(a + jb)$, are housed in a sliding drawer on the left-hand side of the cabinet. The element-weighting controls, which are set up to correspond to the parameters $(x + jy)$, are on the top of the control desk on the left-hand side. The setting switch used to orient the uniselector wipers is on the sloping panel, and the associated stepping button which rotates the bank of switches is on the desk below. The output is indicated on the right-hand meter, and the corresponding direction by one of a ring of lamps around the setting switch. Simplified circuit diagrams of various parts of the circuit are shown in Figs. 3 to 7.

Fig. 3. Oscillator and quadrature circuit



Oscillator and Quadrature Circuit

A frequency of approximately 1kc/s is generated by means of a Wien-bridge oscillator; the circuit diagram is shown in Fig. 3. Since the frequency affects the characteristics of the phase-shifting networks, it is adjustable over a small range by means of a pre-set resistor in one of the reactive arms of the bridge. V_{14} and V_{15} form a resistance-capacitance coupled amplifier, the output of which is fed back to the bridge circuit. A thermistor is used as one of the resistive bridge arms; this stabilizes the oscillator amplitude and also ensures that the amplifier works under quasi-linear conditions, so that the harmonic distortion of the output waveform is kept low (the total harmonic distortion is about 0·5 per cent).

The oscillator is coupled to two cathode-followers through resistance-capacitance phase-shifting circuits such that one output leads and the other lags by 45°; two outputs of the same amplitude in phase quadrature are thus available.

The Pattern-Setting Controls

The outputs from the cathode-followers, V_{16} and V_{17} in Fig. 4, are each connected to a transformer with a centre-tapped secondary balanced to earth, giving four outputs which have relative phase angles of 0° and 180°, 90° and 270°. These energize banks of potentiometers which are set to give output voltages proportional to the real and imaginary components of the complex radiation pattern of a single element; the 0° and 180° phases correspond to positive and negative real components, and the 90° and 270° phases to positive and negative imaginary components. There are thirteen pairs of potentiometers, corresponding to an arc of 180° at 15° intervals; this number is sufficient because, as explained later, advantage can be taken of the symmetry of the radiation pattern of the element. Each potentiometer is associated with a 'sign' switch which selects the appropriate phase,

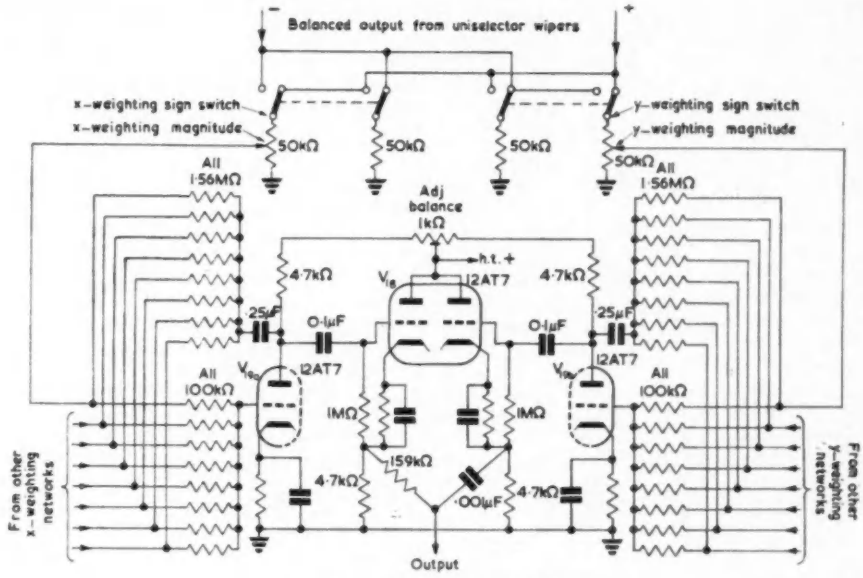


Fig. 5. Element-weighting and adding circuit

and at the same time loads the unused phase with a resistance equivalent to the potentiometer, thus maintaining constant and symmetrical load conditions on each cathode-follower transformer. The setting-up process is carried out with the aid of the output meter, as explained later.

The output from each pair of potentiometers is connected through a resistive mixing circuit to a cathode-follower, the output load of which is a transformer with an earthed centre-tap on the secondary. Each cathode-follower therefore provides an output which is proportional to $(a + jb)$ for one given direction. To reduce the effect of the change in source impedance presented to the mixing circuit by the potentiometers, feedback is employed from one side of the transformer output winding; the other side is loaded with a resistor equivalent to that of the feedback circuit, in order to preserve symmetry. The feedback also has the advantage of electrically decoupling the two sliders of the potentiometers.

The balanced output from the cathode-follower associated with each pair of potentiometers is fed to two banks of contacts of the rotary uniselector switches. The thirteen cathode-followers are connected to contacts 1 to 13 (corresponding to directions 0° to 180°), contacts 14 to 24 (corresponding to directions 195° to 345°) being normally connected through a twenty-two pole two-way switch to contacts 12-2 respectively. This switch permits the polarity of signals fed to contacts 14 to 24 to be the same as that for contacts 12-2 (the requirement for vertical* and tangential elements), or to be reversed (the requirement for radial elements). This change-over is required because for vertical or tangential elements the radiation is symmetrical, whereas for radial elements it is skew-symmetrical, with respect to a plane through the centre of the element and the axis of the mast.

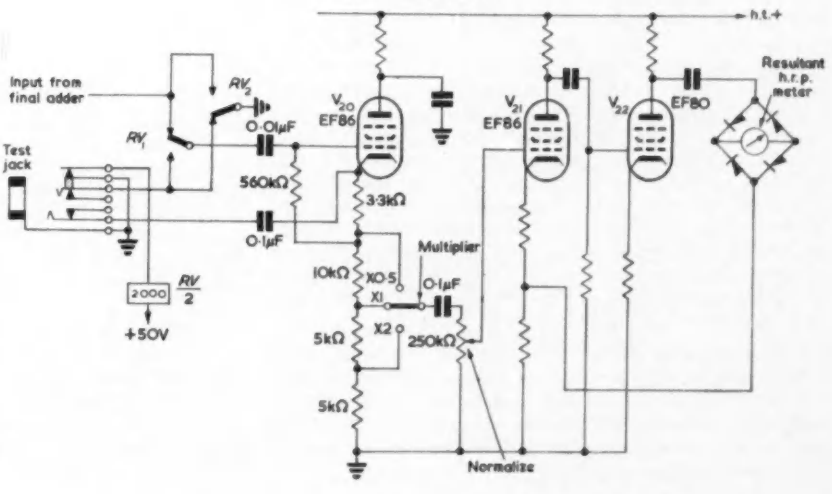
* *The axis of the system is taken to be vertical.*

The Element-Weighting Controls

The outputs from the uniselector wipers are applied to the element-weighting potentiometers (shown in Fig. 5), to permit the amplitude and phase of the current in each element to be taken into account. Two potentiometers are associated with each element, one corresponding to the real and the other to the imaginary component (x and y respectively) of the current in the element. The potentiometers are set up by means of a calibration key which disconnects the normal circuit, applies a d.c. supply, and connects the wiper to a d.c. meter.

The output voltages from all the x-weighting potentiometers are combined in a resistive circuit, and the sum amplified by one half of the double triode, V_{19a}, in Fig. 5. In the same way the other half, V_{19b}, amplifies the sum of the outputs from the y-weighting potentiometers. In both cases a resistive feedback network is provided to reduce interaction between the weighting controls, as in the circuits associated with the pattern-setting potentiometers. The outputs of the adding networks are applied to two cathode-followers (V_{18} in Fig. 5); the two cathodes are connected by a network which advances the phase of the y-output relative to that of the x-output by 90° before adding.

Fig. 6. Output circuit



The Output Circuit

The output circuit is shown in Fig. 6. After amplification and detection the modulus of the output is indicated on a meter. As it is usually convenient to have the output normalized with respect to the maximum value, the amplifier is provided with an adjustable gain control; this enables the maximum reading to be set to full scale on the meter. The effective range can be extended by means of a switch which provides ±6dB steps in the indication.

The output circuit is also used in adjusting the pattern-setting controls. Connexions to the wipers of these controls are provided by the test points, which are shown in Fig. 4. These can be connected to the output circuit by means of a test lead, the controls being adjusted in turn to the required value; the need for calibrated potentiometers is thus avoided. Moreover, the effect of the finite load on each potentiometer is automatically taken into account. The test lead is made of double-screened cable, the inner screen being connected to the cathode of the first ampifying valve, and the outer screen to earth. This prevents hum and other stray pick-up, while the double-screen arrangement reduces the effective stray capacitance of the screened cable.

Operating Facilities

In the design of some aerials the radiation in a limited number of directions is of special importance. It is then convenient to be able to derive these values rapidly, in order to decide whether it is worth while exploring the complete radiation pattern. This facility is provided by a 'hunt' key which rotates the whole set of elements until element 1 is in the selected position indicated by the window of the setting switch.

It is sometimes necessary to work on two independent problems at the same time. Two banks of pattern-setting potentiometers (bank *A* and bank *B*) have therefore been provided, and either may be used for the basic type of computation described; one radiation pattern can be 'stored' while the other is being used, thus avoiding repeated setting-up of the same patterns.

Banks *A* and *B* may also be used in association, in a number of ways. Bank *B* may be set up to correspond to the radiation pattern of a single element at bearings differing by 7½° from those of the main bank; it is thus possible to obtain the radiation pattern of the array at angular intervals of 7½°. Alternatively, the two banks may be used when the aerial element has an asymmetrical radiation pattern. The pattern for the range of bearings 0° to 180° is set up on bank *A* and that for the range 195° to 345° on bank *B*. Again, if bank *A* potentiometers are set up to correspond to the radiation pattern of one type of element, and bank *B* to correspond to that of a different type (for instance, an element having a different spacing from the axis) the radiation patterns of combinations of such elements can then be derived.

In passing it may be mentioned that the speed of setting up could be increased, and at the same time the accuracy improved, by using tapped transformers in place of the pattern-setting potentiometers; three transformers in place of one potentiometer would offer the facility of rapid setting to an accuracy of 0·1 per cent, but at the expense of circuit complication. A combination of transformers and potentiometers is also possible.

Switching Control Circuit

A simplified circuit diagram of the switching control system is shown in Fig. 7. It is intended to demonstrate only the principle of setting, stepping and associated facilities; a great deal of the inter-connecting circuits have therefore been omitted.

The eight uniselectors are designated *A* . . . *H*, but for clarity their circuits are omitted where repetitive in character. In the description that follows it is assumed that all eight uniselectors are in operation; in practice, however, the bank selector switches are arranged to keep in circuit only those required for the number of elements in the array.

Uniselectors

Each uniselector has eight banks of contacts, with twenty-five contacts in each bank, distributed over an arc of just under 180°. It has a rotating shaft, located at the centre of the arc of contacts, carrying eight wipers and slip rings; it therefore acts as a twenty-five way eight-pole switch. Current is conveyed to the wipers by means of spring-wire brushes. All wipers are double-ended, i.e. each has two contacts 180° part; thus when one end of the wiper leaves contact 25 the other moves on to contact 1, so that each wiper connects with all contacts twice per revolution of the shaft.

The shaft is driven by means of a fifty-tooth ratchet wheel and pawl. It is operated by an electromagnet (*MA* . . . *MH* in Fig. 7(b)) which lifts the pawl over one tooth, against the pull of two springs. On release of the magnet the springs restore the pawl and in so doing move the wipers on by one step; the wipers thus step forward only when the magnet is released, not when it operates. A fixed detent prevents backwards rotation, and a fixed stop locks the pawl against the ratchet wheel when the magnet is released, so preventing over-shooting. Just before the pawl passes over the edge of a tooth on the ratchet wheel, a pair of auxiliary contacts (*A*/1 . . . *H*/1 in Fig. 7(b)) is opened by an extension of the magnet armature; they close again when the magnet is fully released. One of the main purposes is to enable the uniselectors to step round repeatedly as long as a voltage is applied to the electromagnet in series with the auxiliary contacts; when the uniselector is correctly adjusted self-driving occurs at a speed of 50 to 60 steps per second. Of the eight banks of contacts, two are used for switching control purposes, and four are used in the computing circuits; the banks of each uniselector have the following functions:

Bank 2 (Bridging wiper)	Stepping
Bank 3	Hunting setting and position indicating
Bank 4, Bank 5	Balanced input from pattern-setting controls of bank *A**
Bank 6, Bank 7	Balanced input from pattern-setting controls of bank *B*

Banks 1 and 8 are not used

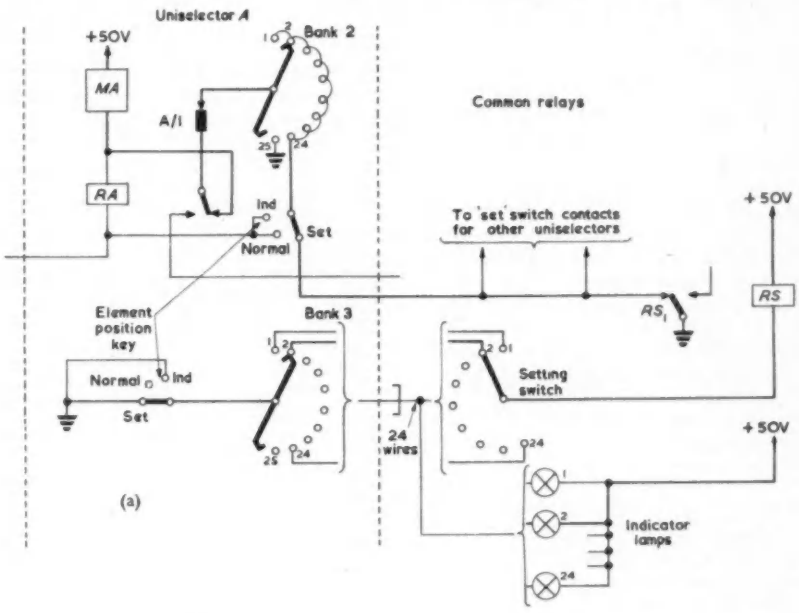
Setting and Lamp Indication

Fig. 7(a) is a simplified circuit diagram showing only those parts connected with the initial setting and indication of the wiper positions. With the element-position key of one of the uniselectors in the 'set' position, as shown in the diagram for uniselector *A*, the contacts of bank 2 are earthed via the contacts of relay *RS*. (The reason for the direct earthing of contact 25 is given later.) The wiper of bank 3 is also switched to earth. Under these conditions the uniselector self-drives until the wiper position corresponds to the setting-switch position. An earth is then applied to relay *RS* via the setting switch and the wiper of bank 3; this disconnects the bank 2

* *When computing with elements having an asymmetrical pattern, uniselector banks 4 and 5 have inputs derived from both A and B pattern-setting controls.*

contacts from earth and further stepping of the uniselector is prevented.

The contacts of bank 3 are also connected to the 50V supply via a set of twenty-four indicator lamps. These are arranged in a ring round the setting switch, and indicate the bearing which corresponds to the wiper position. The 'indicate' position of each of the element-position keys allows a lamp to light according to the position of the element corresponding to the key, but does not initiate the setting operation just described.



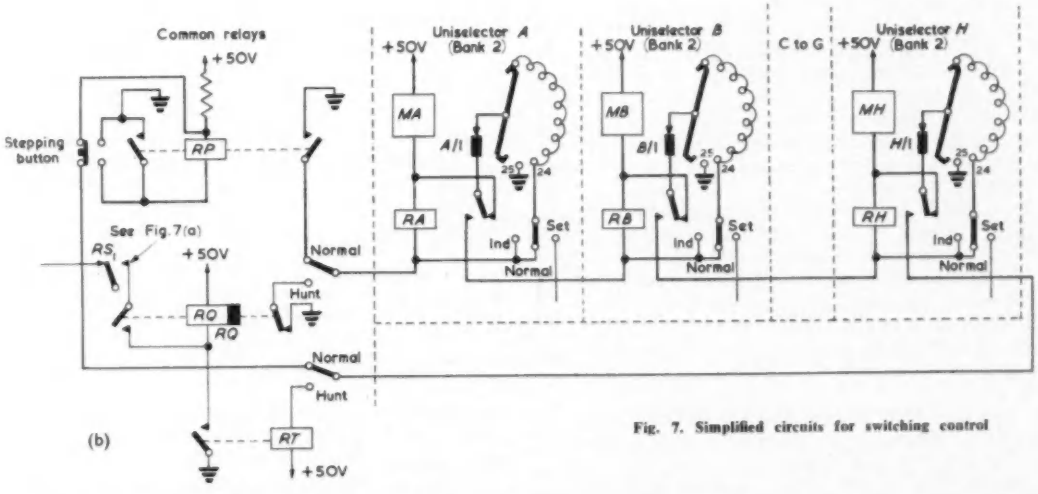


Fig. 7. Simplified circuits for switching control

STEPPING CIRCUIT

Fig. 7(b) is a simplified diagram of the circuit arrangement for stepping the uniselectors. When the stepping button is pressed relay *RP* operates and closes two pairs of contacts. One pair prevents the release of *RP* until the last uniselector has operated; the other applies an earth to the input of uniselector *A*. This causes the magnet *MA* to operate through the closed contacts *A*/1. At this time the coil of the relay *RA* is short-circuited and therefore inoperative. As the uniselector pawl falls over a tooth on the ratchet wheel contacts *A*/1 open, causing the electromagnet *MA* to release and move the wipers of uniselector *A* one step. (The impedance of *MA* is small compared with that of *RA*.) At the same time relay *RA* operates, preventing any further operation of the electromagnet and applying an earth to the input of uniselector *B* via the re-made contacts *A*/1; a similar cycle is then repeated for uniselector *B*. The stepping process continues until relay *RH* operates; provided the stepping button is released the *RH* contacts short-circuit relay *RP*, and so release it. The relays *RA* . . . *RH* are then released in preparation for the next operation of the stepping button.

This arrangement ensures that only one step can be made at a time and that all uniselectors have time to make one step, independent of the time for which the stepping button is pressed. Furthermore, the steps are made sequentially rather than simultaneously, in order to reduce the power consumption to that of one uniselector only.

As only twenty-four of the twenty-five contacts are required, any uniselector which has reached contact 25 must be automatically stepped one further step to contact 1, without impulsing the next uniselector. It is for this reason that contact 25 is in each case provided with a direct connexion to earth as shown in Fig. 7(b). Suppose uniselector *A* wiper arrives at contact 25. All the subsequent selectors then operate and on release of the stepping button the relays are released as before except that, when *RA* releases, the earth on contact 25 causes uniselector *A* to step once again; however, the subsequent selectors do not operate since there is no input

earth connexion to pass on. Similarly, any uniselector which steps on to contact 25 is automatically stepped on to contact 1 as the last stage in the stepping cycle.

HUNTING

Hunting is the process of continuously stepping the uniselectors as a group, as distinct from taking one step at a time, thus enabling the position for a selected bearing to be reached quickly. The element-position key for element 1 is kept switched to the 'indicate' position, thus earthing the bank 3 wiper of uniselector *A*.

When the hunt key is operated an earth is applied to the bank 2 contacts of uniselector *A*, as for stepping, but via the contacts of relay *RQ* (Fig. 8(b)). In addition a contact of relay *RH* associated with the final uniselector is connected to relay *RT*, which in turn controls the operation of relay *RQ*. The uniselectors then form a ring-type circuit in which the completion of one stepping cycles initiates the next cycle. Thus the completion of one cycle is terminated by the energizing of relay *RQ* which removes the input earth. The output earth from *RH* is then removed and the next cycle is initiated by the slow-release relay *RQ* which re-applies the earth to uniselector *A* a short time afterwards.

Repeated stepping continues until the desired 'hunt' position, which is controlled by the setting switch, is reached. When the earthed wiper of bank 3 arrives at the setting switch position, relay *RS* operates and terminates the hunting process by causing relay *RQ* to lock in, instead of slowly releasing.

The Complex Pattern of a Single Element

The raw material on which the computer operates is the h.r.p. of a single element of the array, expressed as a set of complex numbers. In idealized cases the radiation pattern can be calculated. For instance, a theoretical result is available for a doublet mounted on an infinitely-long perfectly-conducting cylinder[1]; this applies also to a perfectly-conducting cylinder of finite length provided it extends sufficiently far beyond radiating elements. This result has been extended to cover the cases of vertical and tangential half-wave dipoles, and of radial quarter-wave unipoles, mounted on a cylinder; a set of tables giving the complex-number patterns for a range of cylinder radii and dipole spacings has been prepared, using a digital computer[2].

A regular polygonal mast can be regarded as equivalent to a cylinder having the same capacitance per unit length, provided the cross-sectional area is sufficiently small. An approximate theoretical method has been published for polygonal masts of large cross-sectional dimensions[3].

In those cases where a theoretical result is either not available or difficult to compute, the complex radiation pattern may be measured[4], for instance by using a small-scale model.

If the radiating elements are of a simple type (for example half-wave dipoles) the effect of mutual interaction between them is automatically taken into account by specifying tue currents in individual elements, although the realization of the correct current ratios remains a problem for the designer of the distribution feeder system. However, calculations based on the addition of element patterns do not in general include the effect of re-radiation from the supporting arms, or from the elements themselves if these are of a complex type. Fortunately, these effects are negligible in many practical cases. Moreover, in certain other cases, namely when similar elements are disposed at equal angular intervals round the mast, the pattern of one element may be determined experimentally in such a manner that re-radiation effects are included.

The computer can also be used if the radiating elements consist of longitudinal slots in a cylindrical mast. Here, in the case of half-wave slots, the feed voltage rather than the feed current must be regarded as determining the weighting factor; this takes account of mutual interaction, being analogous to specifying the current in the case of half-wave dipoles. Sinclair[5] has given a theoretical result for the pattern of a longitudinal slot in a cylinder.

The Converse Problem

The computer described assists in solving problems only on a 'trial and error' basis; the operator feeds in a proposed arrangement and the computer gives the performance. If the result is unsatisfactory the operator, guided by judgement and experience, feeds in a different proposal and so on, until a satisfactory solution is obtained.

It would be much better if a machine could be designed to solve the converse problem, namely to find the simplest way of achieving a prescribed radiation pattern. Although this is theoretically possible there is not a unique solution, and finding the simplest system which satisfies the requirements presents formidable difficulties.

It is clearly unnecessarily restrictive to specify the precise shape of the radiation pattern; a tolerance in the e.r.p. is usually permissible, and it is desirable to take advantage of this to achieve the most economical design. The tolerance may be large in some directions and small in others, but it would entail great complication to make a machine exercise judgement in this respect. Since only the modulus of the radiation pattern need be specified, the best a computer can do is first to calculate the pattern for a chosen number of radiating elements, and then to derive a factor proportional to the overall deviation from the required pattern; some means would then have to be devised to adjust the weighting controls to minimize the deviation factor. (The deviation calculation could be processed to correspond to the degree of importance of the deviation in different directions.) The process is then repeated for an increased number of radiating elements until a satisfactorily small overall deviation is achieved. There is an added difficulty in that, for a given number of radiating elements, there may be more than one condition corresponding to a minimum deviation (in the mathematical sense), and it is necessary to search for the smallest minimum. Again, a particular solution found by the computer may entail relationships between the currents in the radiating elements which are difficult to achieve with practical circuits. These difficulties suggest that the best compromise may well be a simple computer of the type described, the operator exercising judgment in deciding the tvpe of array to be investigated.

If required, the computer may be used in conjuction with any visual display of the type used to show experimental patterns of aerials—for example a polar display with a long-persistence cathode-ray tube.

Acknowledgment

The authors wish to thank the Director of Engineering of the British Broadcasting Corporation for permission to publish this article.

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A High Speed D.C.-A.C. Servo Drive Unit

By B. A. Unvala*, B.Eng. and B. T. Denvir†

The prototype servo unit described was required to operate a 10W a.c. servo motor from a low voltage input over the frequency range d.c. to 70c/s. The circuit comprises a diode ring modulator switched at 400c/s, followed by an a.c. amplifier incorporating phase-shift and limiter networks. The modulator uses silicon rectifiers, and the amplifier is completely transistorized using silicon transistors throughout. The power supply circuit is also described.

(Voir page 264 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 271)

THE unit described here was required to drive a 400c/s servo motor type 18M-10D/2, which incorporates a built-in tachometer. A schematic diagram of the system is shown in Fig. 1.

The modulator consists of a diode ring modulator, preceded by a transistor stage with high input impedance operating from a low impedance source. The modulator

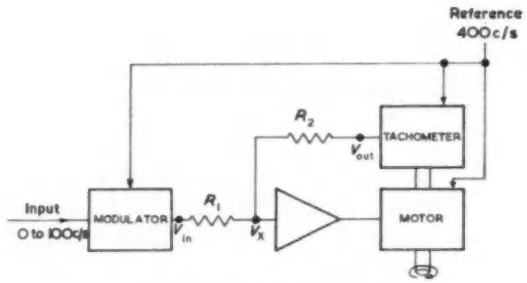


Fig. 1. The complete system

is switched at 400c/s by the reference signal, and the r.m.s. value of its output is required to be constant for input signal frequencies from zero to 70c/s.

The amplifier is required to give sufficient gain to drive the motor at the full rated power of 10W and must introduce the necessary phase-shift with respect to the reference signal. In addition, since the feedback from the tachometer decreases as the speed of the motor is reduced by mechanical loading, a limiting circuit is incorporated to protect the motor against overloading.

A power supply circuit is also included operating from a 400c/s 115V source to give the a.c. reference and modulator switching signals, and the d.c. bias voltages. The complete unit was required to operate over the ambient temperature range 30°C to 40°C, but since silicon devices are used minor modifications in other components would make it possible to operate the unit at temperatures up to 90°C.

Feedback System

The tachometer feedback is used to improve the linearity, the frequency response and the stability of the system. Referring to Fig. 1, the output from the tachometer at the maximum speed of 4500 rev/min is 13·95V. Without feedback from the tachometer the gain of the amplifier from the amplifier input to the tachometer output is 46·5dB, so that the input is 67mV. With a feedback factor of 10 the gain of the modulator can be near unity In fact it was 0·87, and the maximum a.c. input was 0·74V. Thus the r.m.s. value of the fundamental component of the output from the modulator is 0·644V.

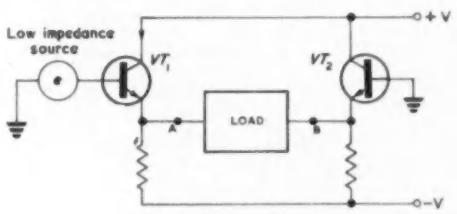


Fig. 2. The input stage

Therefore, referring to Fig. 1:

$$\frac{V_{in} - V_x}{R_1} = \frac{V_x - V_{out}}{R_2}$$

at maximum signal condition.

That is:

$$R_2/R_1 = \frac{13{\cdot}95 - 0{\cdot}067}{0{\cdot}644 - 0{\cdot}067} \simeq 24$$

and the feedback factor is:

$$\frac{0{\cdot}644}{0{\cdot}067} = 9{\cdot}65$$

In practice, a small capacitance was connected in parallel with R_2 to correct a slight phase inaccuracy in the tachometer output voltage.

The Modulator

Input Stage

The basic circuit of the input stage is shown in Fig. 2. This balanced circuit was used to reduce the effect of drift of d.c. levels due to changes in transistor parameters with temperature. In addition the common-collector configuration ensures a high input impedance. Since the input voltage may be either positive or negative with respect to earth the emitter resistors are taken to a negative supply rail.

* *Texas Instruments Ltd.*
† *Formerly with Texas Instruments Ltd.*

The complete modulator circuit is given in Fig. 3, showing the full input stage. The potentiometer RV_2 allows adjustment for zero output with the input short-circuited, to counteract small differences in the base-emitter voltages of the two transistors, and to correct for unbalance in the diode ring modulator. Adjustment of potentiometer RV_1 ensures that the base of VT_1 is at earth potential when the input is open-circuited. The diodes MR_1 and MR_2 protect the transistor VT_1 against accidental voltages surges from the source.

Diode Ring Modulator

The voltage for switching the diodes (0·9V-0·9V) is taken from a separate winding on the power supply transformer and the 10Ω resistor in series with each diode is included to restrict the diode current to 90mA. The modulator output is taken through a 1:1 transformer with the primary centre-tapped. Thus the square wave output voltage has an r.m.s. value (and also peak value) equal to the d.c. input voltage to the modulator, and is in phase with the reference signal.

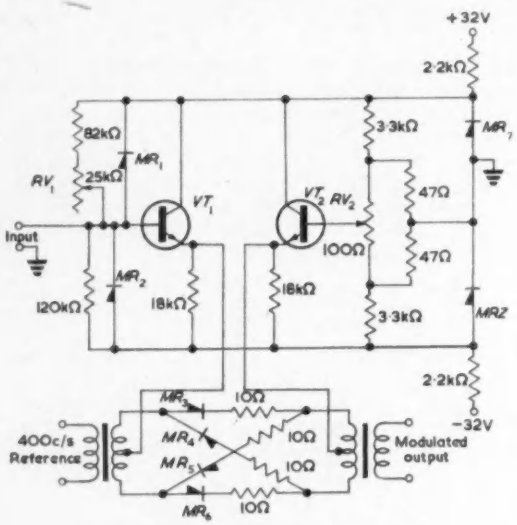


Fig. 3. The complete input stage and modulator

Input Impedance

The input impedance of the diode ring modulator is approximately equal to the impedance at its output (the series resistances and transformer winding resistance being negligible); that is 3·3kΩ. Consequently the input impedance of the input stage is $\beta \times 3{\cdot}3k\Omega$ in parallel with the resistance of the potentiometer chain. This gives a minimum total input impedance of 20kΩ.

Gain

The gain of the common collector input stage is 0·954. Since the r.m.s. value of the fundamental component of a square wave is 0·91 times the r.m.s. value of the square wave the overall gain of the modulator is $0{\cdot}954 \times 0{\cdot}91 = 0{\cdot}87$.

The Amplifier

The amplifier contains the following stages:

(1) Phase-shift network

(2) Pre-amplifier

(3) Limiter

(4) Power amplifier.

A block schematic diagram is given in Fig. 4, where the feedback from the tachometer to the amplifier input is indicated. Feedback is also applied over the pre-amplifier and the power amplifier stages individually to stabilize their gains.

Phase-Shift Stages

The current output from the amplifier is required to be 90° out of phase with the current in the reference windings.

The phase changes introduced between the reference voltage and the current in the control windings, by the modulator, the pre-amplifier and the power amplifier, are simple phase reversals. Hence, the necessary adjustment of the phase of the input to the pre-amplifier is determined by the relative phases of the reference voltage and the current in the reference winding. The impedance of the reference winding of the motor is $(250 + j\,550)$ ohms so that the reference current lags the reference voltage by an angle $\tan^{-1}(550/250)$. Consequently, the control current, and hence the voltage input to the pre-amplifier, must lead the reference voltage by an angle $\tan^{-1}(250/550)$, or 24·4°.

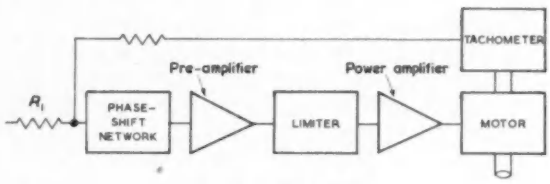


Fig. 4. The amplifier stage

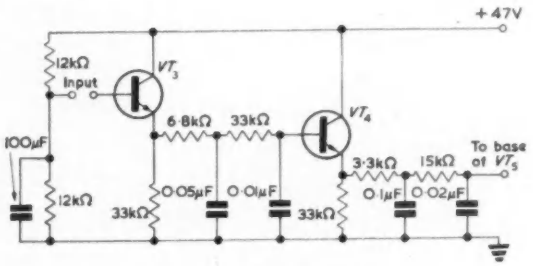


Fig. 5. Phase-shift network

The square wave output from the modulator has a second harmonic content due to the non-linear magnetic characteristic of the core of the output transformer. A phase lead network would accentuate this second harmonic and overload the motor and the output stage under maximum signal conditions. For this reason a 155·6° lag network is used, and this effectively attenuates the harmonics.

The phase-shift circuit is shown in Fig. 5. As a compromise between economy of components, low attenuation and low necessary component tolerances, a four stage lag circuit was used with two common-collector buffer stages. If the phase-shift stages were not loaded the total attenuation would be 2·85; in fact the attenuation is increased to 4·3 by loading. Using 1 per cent resistors and 2 per cent capacitors the tolerance of this attenuation is ±9 per cent. This is further increased to ±13·6 per cent by the tolerance of the supply frequency.

The component tolerances introduce a phase-shift tolerance of $\pm 3{\cdot}2°$, and this is further increased to $\pm 7{\cdot}2°$ by the tolerance of the supply frequency. Since an inaccuracy of θ in the phase-shift decreases the torque in the motor by a factor $\cos\theta$, this increases the effective gain tolerance of the complete system by $\pm 0{\cdot}5$ per cent.

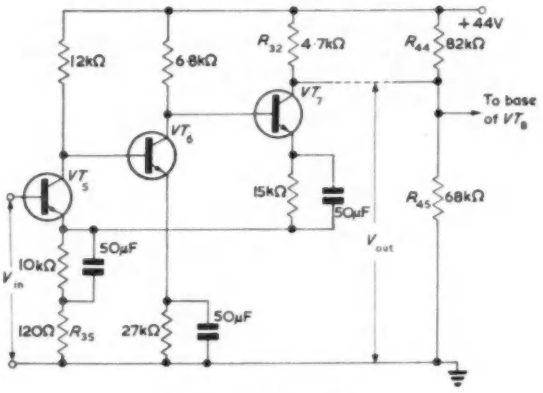


Fig. 6. Pre-amplifier circuit

Fig. 7. The limiter

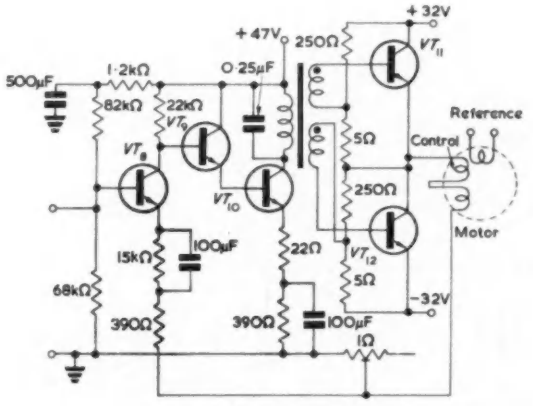


Fig. 8. The power amplifier

Pre-Amplifier

As previously stated the input to the pre-amplifier when the motor is running at maximum speed is 67mV and, in fact, the limiter restricts the input to the power amplifier to 0·65V peak. In the phase-shift stages, with an attenuation of 4·3, the ratio of peak 400c/s output to peak square wave input is, $4/(\pi \times 4{\cdot}3) = 1/3{\cdot}38$, so that the gain of the pre-amplifier must be:

$$\frac{650 \times 3{\cdot}38}{67} = 32{\cdot}6$$

The pre-amplifier must also have a high input impedance to avoid loading the last stage of the phase-shift network. Furthermore, the output impedance must be considerably greater than the forward resistance of the limiter diodes, for efficient limiting, and considerably less than the input impedance of the power amplifier. These conditions are achieved by using series current feedback, excluding the load resistance of 4·7kΩ from the feedback loop. Thus the output impedance is approximately 4·7kΩ in parallel with the output impedance of the transistor.

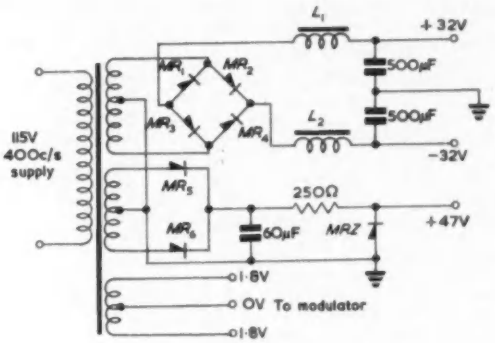


Fig. 9. The power supply

The circuit of the pre-amplifier is shown in Fig. 6. In this circuit the feedback factor is sufficiently large to make the gain approximately equal to:

$$R_L/R_{35} = \frac{R_{32}R_{44}R_{45}}{R_{35}(R_{32}R_{44} + R_{44}R_{45} + R_{45}R_{32})} \simeq 35$$

Using 1 per cent resistors for R_{32} and R_{35}, and taking the tolerance on current gain to be $\pm 1{\cdot}25$ per cent, the tolerance on the gain of the amplifier is $\pm 3{\cdot}25$ per cent.

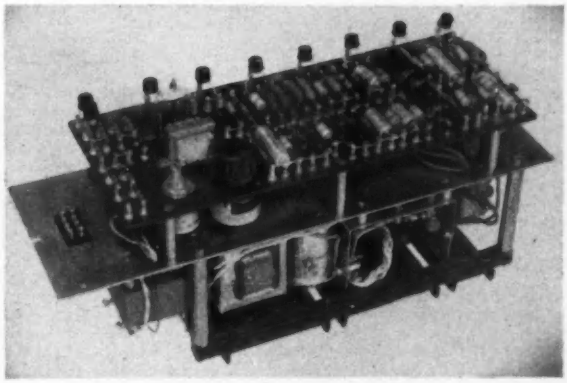
The input impedance of the amplifier with feedback applied is:

$$Z_{in} = \beta_5\{h_{ib5} + 120(1 + \beta_6\beta_7)\}$$

where β_5, β_6 and β_7 are the common-emitter current gains of VT_5, VT_6 and VT_7 respectively and h_{ib5} is the common-base input impedance of VT_5. Thus, assuming a minimum β current gain of 20 for all transistors, the minimum input impedance is approximately 960kΩ.

The pre-amplifier is designed to work satisfactorily with a range of d.c. bias voltages to allow for the spread of β values for VT_3, VT_4 and VT_5, and for the spread of base-emitter voltages for VT_3 and VT_4.

Fig. 10. The prototype unit



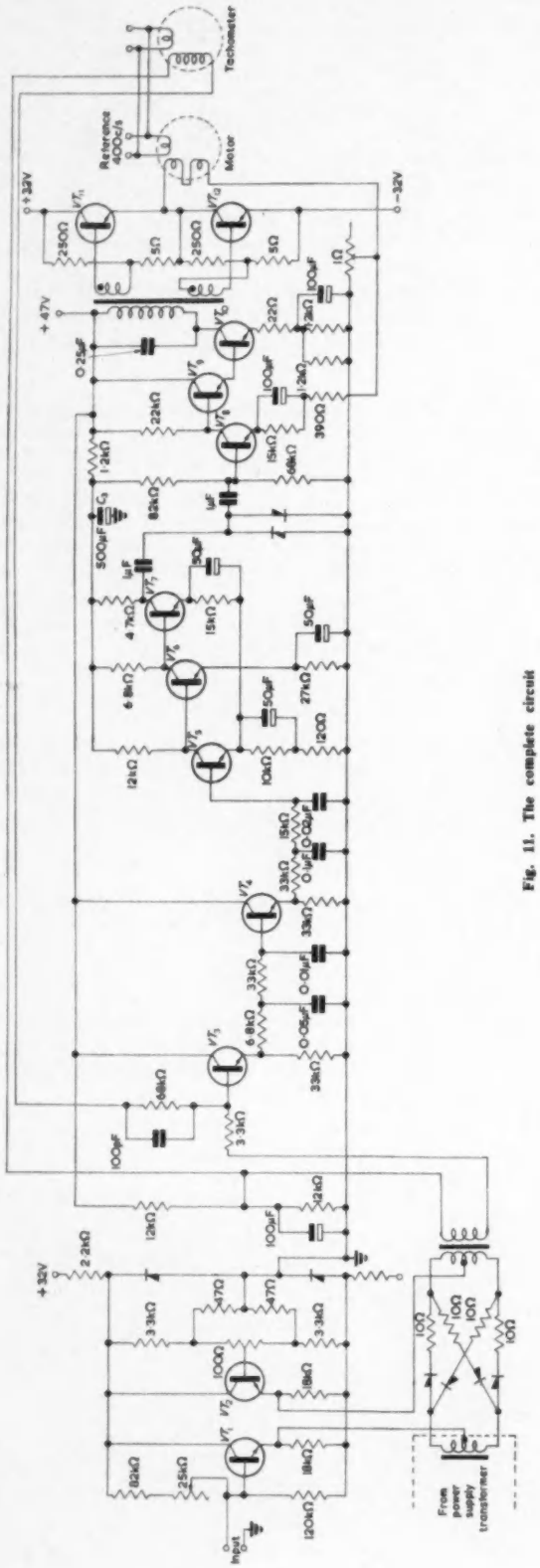


Fig. 11. The complete circuit

The Limiter

The circuit of the limiter is shown in Fig. 7. Many different types of diodes were examined to determined which were most suitable for this application. It was found that the forward characteristic of low voltage Zener diodes gave the sharpest limiting and the most consistent voltage drop (650mV ± 5 per cent).

The Power Amplifier

The circuit of the power amplifier is given in Fig. 8. A silicon medium power transistor type 2S017 (VT_{10}) is used to drive a pair of silicon power transistors type 2S012 in class-*B* push-push. This push-push arrangement,

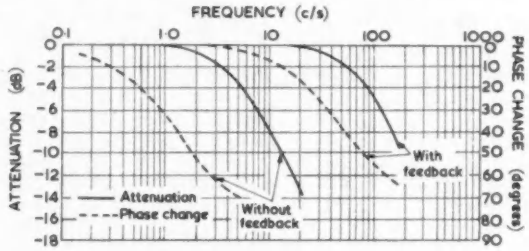


Fig. 12. Attenuation and phase-shift of output with and without tachometer feedback

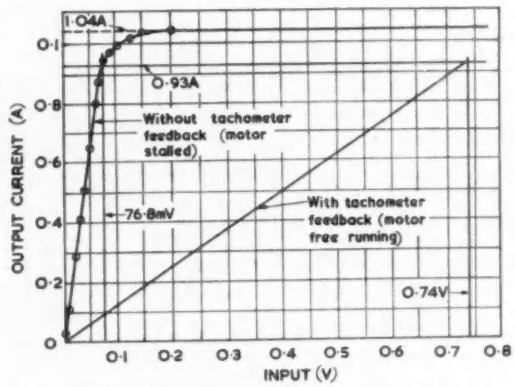


Fig. 13. Variation of output current with input voltage with and without tachometer feedback.

with a centre-tapped power supply, makes it possible to take a feedback voltage from a low resistance in series with the load, and avoids the use of the centre-tap of the control winding.

The input impedance of the power amplifier must be high to avoid loading the limiter. A 2S004 transistor is used in the input stage with a small amount of emitter degeneration. Since 2S017 driver transistor has a fairly low input impedance a 2S002 transistor in common-collector configuration is interposed between it and the input stage.

The input impedance of the amplifier is increased by feedback from the output to the emitter of the input stage. The feedback voltage is produced across a resistance of 0·706Ω in series with the control winding of the motor. The feedback also increases the output impedance of the amplifier, and thus provides constant load current. Since the load is partly inductive the time-constant of the output circuit is L/R_{out}, where L is the inductive com-

ponent of the load and R_{out} the output impedance. Thus the increased output impedance improves the frequency response, and hence the transient response.

With no feedback applied the maximum input voltage for full output is 13mV and the minimum input impedance is 14kΩ. When feedback is applied the equivalent figures are 650mV and 700kΩ.

When the amplifier is delivering the full rated power to the motor the current in the motor lags the voltage across it due to the inductive component of the load impedance. This doubles the peak volt-amperes handled by the transistors by comparison with that for delivering the same power to a resistive load. The peak-to-peak voltage swing is 56·5V and the peak-to-peak current swing 2·64A.

Thus the output power is:

$$R_{out} = V_{rms} I_{rms} \cdot \cos\theta$$

where $\theta = \tan^{-1} R/L$ is 62°12.

Therefore:

$$P_{out} = 20 \times 0{\cdot}93 \times 0{\cdot}466$$
$$\simeq 8{\cdot}7\text{W}.$$

Power Supplies

The power supply transformer has three separate secondary windings and operates from 115V, 400c/s input. The circuit is given in Fig. 9. One secondary uses a centre-tapped bridge circuit to give +32V - 0 - −32V for the output stage of the power amplifier, and for the modulator. Another winding employs a full-wave rectifier circuit to give a stabilized +47V supply for the remaining stages. Finally, a third winding gives the modulator switching signal. The voltage tolerance for the 115V, 400c/s supply is ±2 per cent and the frequency tolerance ±4 per cent.

Conclusion

A photograph of the prototype unit is reproduced in Fig. 10. The complete circuit, given in Fig. 11, has a minimum input impedance of 20kΩ, and there is adjustment for zero speed of the motor with zero input voltage under both open-circuit and short-circuit input conditions. The frequency response of the complete unit (from the modulator input to the mechanical response of the motor) is substantially level from d.c. to 70c/s. The attenuation and phase-shift with and without feedback are plotted against frequency in Fig. 12.

The tolerance of the open loop gain owing to variation in the gain of the phase-shift network, pre-amplifier and power amplifier is ±19·35 per cent or ±1·54dB. It should be stressed, however, that ±17·1 per cent or ±1·34dB variation of gain is caused by the resistor and capacitor tolerances alone.

The components in the phase-shift network are the most important from this point of view, and the accuracy margin of the amplifier can be improved considerably by using closer tolerance components in these stages.

The tachometer feedback may be altered by simply changing the ratio of R_2 to R_1, and the gain of the pre-amplifier. The latter is best done by changing the value of R_{25}. By increasing the tachometer feedback and increasing the loop gain of the amplifier it should be possible to extend the frequency response of the complete system.

The linearity of the variation of output current with d.c. input voltage, and the limiting of the output, are shown in Fig. 13. Curve 1 shows the characteristic with the motor stalled, i.e. without tachometer feedback, and curve 2, that with the motor running freely, i.e. with tachometer feedback.

Radio Guided Tours for the Science Museum

The Ministry of Works has installed at the Science Museum, South Kensington, a system operating on the induction loop principle by means of which tape recorded commentaries can be transmitted over a limited area where they can be received by visitors carrying small receivers.

The system is similar to that used at International Conferences for multi-lingual translation service.

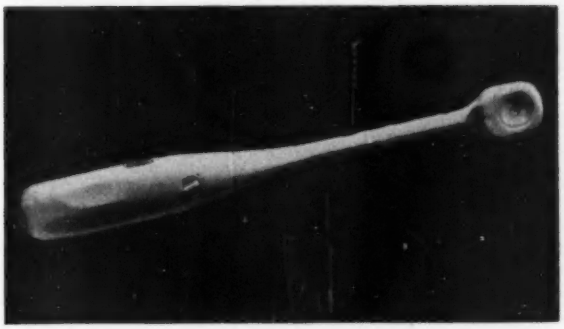
It is stated that this is the first time that a system of radio guided tours has been installed in a national museum and it is expected that it can be adapted for similar purposes for use in art galleries, stately homes and the like.

At the present moment, the Iron and Steel, Electric Power and Sailing galleries of the Science Museum have been equipped but further extensions will be made if this scheme is successful.

A number of advantages over the personally-conducted tour is claimed for this system. The recorded voices of experts in each field of science can be employed to guide parties round the galleries as often as is required, and the recording can be adapted to suit the age and experience of members of parties. At the same time the visitor can enjoy the freedom of a small party, he is able to view the exhibits with greater comfort, and he is able to hear every word of the commentary.

A visitor using the present system has merely to follow the instructions contained in the commentary while making his tour. They take him from display to display.

Each commentary lasts about twenty minutes. Once the system is switched on at the control point it works automatically, the tape recorders in various key parts of the museum playing their commentaries, re-winding their tapes for the next transmission without any attention being necessary.



One of the receivers

The radio guide system has been developed by the Multitone Electric Company Ltd and is based upon the inductive loop principle, which has already become widely used for pocket paging staff location systems. The frequencies allocated for this purpose are 50, 62, 74, and 86kc/s.

The transmitting equipment consists of an automatic tape playback mechanism, the output from which is fed to a pre-amplifier which modulates an oscillator on one of the four frequencies chosen. Where small areas are to be covered, the modulated output from one or more of these oscillators is then fed to the loop of wire encircling the room. Where larger areas have to be covered, the output from the oscillator is fed to a transistorized power amplifier.

The output from up to four of these power amplifiers can again be used in separate loops or mixed on a single loop.

The four frequencies can be used for the spatial separation, or for using four separate languages in a single room, or for the time spacing of visitors as required.

The receiver is enclosed in a grey plastic moulding resembling a lorgnette, about 20in long and about two inches in diameter, and weighing only 7 ounces.

The receiver is operated by transistors and is fed from a single cell battery giving a useful life of more than 300 hours. The receiver and battery are contained at one end of the moulding. At the other end is a small loudspeaker.

Automatic volume control and printed wiring are employed, and the receiver is equipped with a four channel selector switch and a combined on-off volume control.

This hand-held type of receiver eliminates the use of extension cords used with separate earpieces.

Long-Distance Waveguide Transmission

By R. Hamer*, Ph.D.

(Part 1)

The feasibility of long-distance circular waveguide (H_{01}-wave) transmission using frequency modulation is examined, on the assumptions that a special waveguide structure is provided and that waveguide imperfections are random. The fundamental limitations considered are: (a) increase in H_{01}-mode attenuation due to mode conversion at waveguide imperfections; (b) intermodulation distortion arising from parallel-flow and echo signals; (c) dispersion in the waveguide.

The analysis is made with particular reference to multi-channel telephony transmission, since this presents the greatest difficulty; the modulating signal is simulated by random noise.

The results of the analysis are applied to a hypothetical route comprising random jointed sections of 2in diameter copper tubes lined with a lossy dielectric. The resultant intermodulation noise in a telephone channel of a 2 700-channel system is deduced for a range of parameters, at a carrier frequency of 35Gc/s.

It is concluded that the limitations examined do not preclude the use of frequency modulation in long-distance circular waveguide transmission.

(Voir page 255 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 272)

ALTHOUGH the transmission of the H_{01}-mode wave in circular-section waveguide is attractive because of the inherently low attenuation[1], great difficulty is encountered in practical applications, chiefly owing to the effects of mode-conversion and re-conversion[2] (what has been termed 'parallel-flow') and dispersion. This has led to a consideration of rugged modulation systems; in particular, to pulse-code modulation, which does not require a high degree of uniformity in the transmission characteristics of the signal path. The effects of parallel-flow and dispersion are so serious in a practical waveguide structure that the use of pulse-code modulation (p.c.m.) appears to offer the only short-term solution to the problem of long-distance waveguide communication; all known investigations are consequently directed to the use of p.c.m. In spite of this, it is considered that a detailed investigation of the feasibility of using frequency modulation in circular waveguide transmission is of value. The reasons for this are:

(a) F.M. is inherently a much simpler method of modulation, with a background of advanced techniques arising from the development of broadband microwave systems[3].

(b) Any future circular waveguide systems will have to be integrated with the existing highly developed frequency-division multiplex (f.d.m.) telephony systems; this is more readily achieved with f.m., which offers the possibility of direct modulation of the waveguide carriers by f.d.m. baseband signals of very high capacity.

(c) The facility of inserting and extracting large f.d.m. signal blocks at convenient points in a long waveguide system is likely to be more economical when using f.m.

(d) The signal-to-noise ratio in p.c.m. systems is substantially independent of the distance between waveguide terminals; consequently, little difficulty is likely to be encountered in very long routes, since the tolerable noise power recommended by the C.C.I.T.T. is proportional to route length. However, in countries where the centres of dense population are not very far apart, the required performance of p.c.m. terminal equipment may be impracticably high.

When p.c.m. is used, the chief limitation imposed by a practical waveguide is the increase in the H_{01}-mode attenuation due to unwanted coupling to parasitic modes at waveguide imperfections. The effects of parallel-flow and dispersion in producing signal distortion are of secondary importance. With f.m., on the other hand, the latter effects are of primary importance while, at the same time, the need to avoid excessive H_{01}-mode attenuation is just as important as with p.c.m. Furthermore, although H_{01}-mode echoes, due to reflections at small discontinuities in the waveguide, may be neglected in p.c.m. systems, they can be a source of f.m. signal distortion.

It is proposed here to examine the fundamental limitations in the use of f.m. transmission in circular waveguide, and to assess the feasibility of this method. Other problems unrelated to the waveguide limitations also arise in the use of f.m. that are not necessarily present with p.c.m., such as those of amplification and frequency-conversion. These are outside the scope of the present investigation, but it is considered that current developments in electron devices and semiconductors are likely to provide satisfactory solutions in the future. The investigation is based on the following important assumptions:

(1) A special waveguide structure is used, designed to break the degeneracy between the H_{01} and E_{11} modes and to increase the attenuation of unwanted modes† relative to that of the H_{01} mode.

(2) The waveguide is manufactured and laid in such a way as to avoid periodic imperfections and discontinuities. If, as will be assumed, the guide is composed of pre-fabricated sections, then the sections are made random in length (over a convenient range of lengths) and the guide supports are placed at irregular intervals.

The need to remove the H_{01}-E_{11} degeneracy is well known[4], and waveguide structures can readily be devised to do this. Practical waveguide structures also enable the relative attenuation of the unwanted modes, other than H_{on}, to be greatly increased, and this is an essential feature of a satisfactory waveguide, irrespective of the method of modulation used.

The effect of periodic non-uniformities in a circular waveguide has been examined by Rowe and Warters[5], and the importance of avoiding such non-uniformities cannot be over-emphasized.

* *General Post Office Engineering Department.*

† *This can only be done to a small degree for the H_{on} modes.*

PRINCIPAL SYMBOLS

a = differential group-delay per unit length between a parasitic mode and the H_{01} mode
α = attenuation coefficient
$\delta\alpha$ = increment in attenuation coefficient
$\Delta\alpha$ = attenuation coefficient of a parasitic mode relative to that of the H_{01} mode
β = phase-change coefficient
β_o = free-space phase-change coefficient
$\delta\beta$ = increment in phase-change coefficient
$\Delta\beta$ = phase-change coefficient of a parasitic mode relative to that of the H_{01} mode
c_{rms} = r.m.s. wave coupling coefficient due to a large number of random discontinuities
C = curvature of waveguide axis
d = waveguide axis offset
e = relative permittivity
e = ellipticity of waveguide
f = frequency
f_n = highest modulation frequency
Δf = r.m.s. frequency deviation
g = $2\Delta_\alpha u$
l = mean length of waveguide section between joints
L = total length of waveguide
λ_o = free-space wavelength
λ_o = cut-off wavelength in guide
λ_g = guide wavelength
m = r.m.s. modulation index, $\Delta f/f_n$
s = radius of waveguide
σ_{rms} = r.m.s. wave coupling coefficient per unit length due to a large number of random lengths of random distributed coupling
t = thickness of dielectric film
T = delay of echo or parallel-flow signal
T_g = group-delay
$\tan\delta$ = loss tangent of dielectric
θ = $2\pi f_n T$ = echo phase difference at highest modulation frequency
u = $1/2\pi f_n a$
v_o = velocity of light
v_g = group velocity in waveguide
w = mean normalized power transfer per unit length to a parasitic mode
w' = mean normalized H_{01}-mode power loss per unit length
W_D = mean normalized intermodulation noise power density at f_n in the baseband
W_d = mean normalized intermodulation noise power density at f_n in the baseband for unit L and w
χ_{mn} = H_{mn} mode number, i.e. n^{th} root of $J'_m(x) = 0$
z = distance along waveguide axis
η = normalized power of echo or parallel-flow signal
ρ_{rms} = r.m.s. reflection coefficient due to a large number of random discontinuities
ϕ = tilt angle of axis of waveguide at a joint ($\phi = 0$ in straight guide)
ψ = radius taper angle of non-uniform waveguide

The suffixes m, n are used to denote quantities appertaining to the H_{mn} mode, except where otherwise indicated.

The fundamental limitations examined are as follows:

(a) The increase in the H_{01}-mode attenuation due to mode conversion at waveguide non-uniformities.

(b) Signal distortion due to parallel-flow power and reflections at discontinuities.

(c) Signal distortion due to dispersion in the waveguide.

In considering signal distortion, attention is confined to f.d.m. multi-channel telephony modulation, since this requires the highest degree of linearity of any modulating signals that may be envisaged at present. Furthermore, the multi-channel signal is simulated by uniform Gaussian noise, and the resulting performance is expressed as a noise power ratio[6] (n.p.r.). In the numerical results, a modulation frequency band appropriate to a 2 700-channel signal of standard form is assumed, and the band is taken for convenience as zero to 12·5Mc/s.

It transpires that useful results in relation to signal distortion due to parallel-flow can be evaluated only for a particular waveguide structure, and it has therefore been necessary to consider a particular type and size of waveguide. The dielectric-coated copper waveguide[7] has been chosen, and is considered in detail later. Useful data have been evaluated for 2in diameter copper waveguide, with various lossy dielectric films on the internal wall, operating at 35Gc/s. The method of analysis is applicable to other types of waveguide structure, but detailed results can be obtained only with considerable computation for each type considered.

Attenuation Due to Waveguide Imperfections

At waveguide imperfections power is coupled from the H_{01} to other modes having greater attenuation than the H_{01} mode. At such imperfections power is also re-coupled to the H_{01} mode from some of the parasitic modes existing at that point. The first result of such mode-conversion and reconversion is clearly to increase the effective attenuation coefficient of the H_{01}-mode.

Waveguide imperfections are conveniently placed in two categories:

(1) Discontinuities that may be regarded as producing point coupling to a parasitic mode, e.g. diameter steps and offsets at joints.

(2) Imperfections that produce distributed coupling to parasitic modes over a certain length; e.g. bends, ellipticity.

It is convenient also to recognize two types of coupling in the second category:

(a) Comparatively short coupling lengths over which the differential attenuation of the parasitic wave is negligible.

(b) Long coupling lengths (but still treated as short compared with the total waveguide length) over which the differential attenuation is not negligible.

Type 2(a) couplings, and also point couplings in the first category, are associated with imperfections in the individual section lengths, occurring at and between joints. Because the differential attenuation is negligible, the net power loss per unit length is the same as the power transfer per unit length to the parasitic mode. Distributed couplings of type 2(b) are associated with route bends and, in this case, the net power loss over the coupling length is greater than the net power transfer to the parasitic mode.

The extra H_{01}-mode attenuation due to waveguide imperfections may be estimated by calculating the normalized power loss per unit length due to each significant parasitic

mode, and adding the results. It is shown in Appendix (1) that the increment in the H_{01}-mode attenuation coefficient due to coupling to a parasitic mode, in a long waveguide with random imperfections, is:

$$\delta\alpha_{01} \simeq \tfrac{1}{2}w' \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where w' is the mean normalized power loss per unit length. Most of the relevant couplings are of types 1 and 2(a), for which the net normalized power transfer, w, per unit length is equal to w', so w will be calculated for these cases; only for couplings of type 2(b) is it necessary to calculate w'.

Couplings of type 1 give rise to a discrete transfer of power to a particular mode or modes depending on the type of discontinuity. The mean normalized power transfer, w, per unit length throughout a long waveguide with random discontinuities is:

$$w = (c_{rms}^2/l) \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where c_{rms} = r.m.s. coupling coefficient at discontinuities,

l = mean spacing of discontinuities.

Couplings in the second category give rise to a power transfer depending on the length over which the coupling coefficient has the particular value, and on the propagation constants of the H_{01} mode and the parasitic mode considered; the coupling coefficient per unit length is a function of the type and magnitude of the waveguide imperfection. It can be shown[8] that with very small coupling over a length z the power transferred to the parasitic mode is:

$$p = (2\sigma^2/\Delta\beta^2)\ (1 - \cos\Delta\beta z) \quad \ldots\ldots\ldots (3)$$

where σ is the wave coupling coefficient per unit length.

In dealing with short coupling lengths, account must be taken of power returned to the H_{01}-mode, as indicated by the cosine term in equation (3), so the net normalized power loss at the end of a coupling length z is p, as given.

If a long waveguide consists of a very large number of random sections of mean length l, and the r.m.s. coupling coefficient per unit length is σ_{rms}, then the mean power transfer per unit length to the parasitic mode is:

$$w = 2\sigma_{rms}^2/\Delta\beta^2 l \quad \ldots\ldots\ldots\ldots\ldots (4)$$

In a long coupling length it may be assumed that there is an integral number of power transfers between the modes, together with a residual random portion of a transfer cycle. It is shown in Appendix (2) that if the relative attenuation coefficient of the parasitic mode is $\Delta\alpha$, the extra power loss suffered by the H_{01} mode per transfer cycle is approximately:

$$p = (4\sigma^2/\Delta\beta^2)\ (1 - e^{-4\pi\Delta\alpha/\Delta\beta})$$

and the total power loss over n cycles is:

$$p_n = (4n\sigma^2/\Delta\beta^2)\ (1 - e^{-4\pi\Delta\alpha/\Delta\beta})$$

If it is supposed that a coupling length, z, contains n transfer cycles and the residual fraction neglected, then (from equation (3)):

$$z = (2n\pi/\Delta\beta)$$

and the power lost per unit length is:

$$w' = (2\sigma^2/\Delta\beta\pi)\ (1 - e^{-4\pi\Delta\alpha/\Delta\beta})$$

The residual fraction of a cycle, being random, will give rise to a power loss as shown in equation (4), so the total effective power loss per unit length is:

$$w' = (2\sigma^2/\Delta\beta^2 z) + (2\sigma^2/\Delta\beta\pi)\ (1 - e^{-4\pi\Delta\alpha/\Delta\beta})$$

The value of $\Delta\alpha$ is dependent on the design of the waveguide, so it is proposed here to take the extreme case of $\Delta\alpha \to \infty$ which leads to the greatest power loss; then in a long waveguide in which l is the mean coupling length and σ_{rms} the r.m.s. coupling coefficient per unit length, the normalized power loss per unit length is:

$$w' = (2\sigma_{rms}^2/\Delta\beta^2 l) + (2\sigma^2/\Delta\beta\pi)$$

$$w' = w\,[1 + (\Delta\beta l/\pi)] \quad \ldots\ldots\ldots\ldots (6)$$

If $\Delta\beta$ is zero (as with the E_{11} mode in plain metallic waveguide) equation (2) and the succeeding arguments are not valid, all the H_{01}-mode power then being periodically transferred to the parasitic mode and back again[4]. In the present investigation such degeneracy is excluded, as already noted.

The parameter l in the preceding equations requires further examination. In the case of discrete discontinuities, l may be interpreted as the mean section length between joints, since point couplings are unlikely to occur except at joints. With distributed coupling, however, the length l depends on the type of imperfection considered. Long bends in the waveguide route are unrelated to the section lengths, and the value of l then depends on the route considered. The coupling lengths associated with ovality, bow and gradual diameter tapers, although related to, are not necessarily equal to the section lengths. Typical values of the parameter l in relation to a particular waveguide and hypothetical route are considered later.

In considering the H_{01}-mode attenuation due to waveguide imperfections, it is reasonable to regard all power converted to parasitic modes (at a given discontinuity or throughout a given coupling length) as lost, no account being taken of the relatively small amounts of power returned to the H_{01}-mode at subsequent imperfections. In any case, the parallel-flow power will in general be delayed and will not therefore constitute useful f.m. signal power.

TABLE 1

Parasitic-Mode Couplings

MODE	IMPERFECTION	COUPLING COEFFICIENT	REFERENCE
H_{01}	Gradual changes in diameter	$\sigma = 2\left[\frac{\chi_{01}\ \chi_{0n}\ \psi}{(\chi_{01}^2-\chi_{0n}^2)\ s}\right]$	Appendix (3)
	Diameter steps	$c = 2\left[\frac{\chi_{01}\ \chi_{0n}\ \delta s}{(\chi_{01}^2-\chi_{0n}^2)\ s}\right]$	9
H_{11}	Slight bends	$\sigma = 0{\cdot}036 s\sqrt{(\beta_{01}\ \beta_{11})}\ C$	10
	Axis tilts	$c = 2\sqrt{2}\left[\frac{\chi_{01}\ \chi_{11}\ \beta_{01}}{(\chi_{01}^2-\chi_{11}^2)^2}\ s\ \phi\right]$	11
	Axis offsets	$c = \sqrt{2}\left[\frac{\chi_{01}\ \chi_{11}\ d}{(\chi_{01}^2-\chi_{11}^2)\ s}\right]$	11
H_{12}	Slight bends	$\sigma = 0{\cdot}1\ s\sqrt{(\beta_{01}\ \beta_{12})}\ C$	10
	Axis tilts	$c = 2\sqrt{2}\left[\frac{\chi_{01}\ \chi_{12}\ \beta_{01}}{(\chi_{01}^2-\chi_{12}^2)^2}\ s\ \phi\right]$	11
	Axis offsets	$c = \sqrt{2}\left[\frac{\chi_{01}\ \chi_{12}\ d}{(\chi_{01}^2-\chi_{12}^2)\ s}\right]$	11
H_{21}	Ellipticity	$\sigma = \frac{1}{\sqrt{(\beta_{01}\ \beta_{21})}}\ \frac{\chi_{01}\ \chi_{21}^2}{s^2\sqrt{(\chi_{21}^2-4)}}\ \epsilon$	12, 13
E_{11}	Slight bends	$\sigma = \frac{1}{2}\left(\frac{s\beta_0}{\chi_{01}}\ C\right)$	10
	Axis tilts	$c = \frac{1}{2}\left(\frac{s\beta_0}{\chi_{01}}\ \phi\right)$	11

It is now necessary to relate w (or w') to the mechanical imperfections in a waveguide run, using equations (2), (4) and (5). The principal parasitic modes and the imperfections which cause coupling to them, together with approximate formulae for the wave coupling coefficients, are shown in Table 1. References are given in the Table to the sources from which the formulae have been derived, and an approximate analysis of gradual diameter tapers is given in Appendix (3). In the mode notation the suffixes m, n refer to H modes except where otherwise indicated; the ellipticity is defined as:

$$\epsilon = \frac{D_{max} - D_{min}}{D_{max} + D_{min}}$$

where D is the waveguide diameter, and a small radius step is denoted by δs.

Before any further progress can be made in estimating the additional H_{01}-mode loss due to waveguide imperfections, it is clearly necessary to specify the waveguide tolerances and operating frequency. Attention is therefore now confined to transmission at 35Gc/s in 2in diameter waveguide, and a very long run having random imperfections is assumed. The r.m.s values of the waveguide distortions in the formulae in Table 1 are then appropriate. In order to arrive at realistic figures for the waveguide distortions, a hypothetical waveguide route following a typical modern trunk road is postulated, and the waveguide is assumed to be composed of short lengths of drawn copper tube*. The dimensions of specimen lengths of copper tube have been measured, and the tolerances appropriate in jointing such tubes have been examined. On this basis the mean power coupling coefficients have been calculated using the formulae in Table 1, and the results are shown in Table 2. Data on route curvature have been taken from Ministry of Transport 6in to 1 mile maps of a new trunk road. The following assumptions have been made:

(1) The section lengths vary between 2m and 6m, the mean length being 4m;

(2) Waveguide supports are spaced at irregular intervals, the mean spacing being 2m;

(3) The jointing is systematic to minimize steps in ellipticity, the effect of such steps being neglected.

The waveguide parameters required, together with others referred to later, are shown in Table 3. The value of β_0 is taken as 733rad/m and $\Delta\beta_{E11}$ is assumed to be 1rad/m. The values of w shown in Table 1 have been doubled (except for the H_{0n} modes) to allow for orthogonal modes. This is probably pessimistic, since bends due to tube bow are likely to be less in the horizontal plane and route deviations in the vertical plane are usually less than those in the horizontal plane. The plane of the major axis of the ovality in the tube specimens examined varied in a random manner, and the ovality distortion was rarely found to be truly elliptical. The value of ϵ shown in Table 2 corresponds to the resolved component of ellipticity in one plane, estimated from sample measurements. In the tubes examined, the mean length over which the ovality was substantially constant was found to be about 1m. The main component of gradual diameter change was found to be a substantially linear taper throughout the length of each tube.

The total effective power loss per metre is about $3{\cdot}2 \times 10^{-5}$; hence, from equation (1), the increment in the H_{01}-mode attenuation coefficient is 0·000016N/m. This is about 7 per cent of the theoretical attenuation coefficient* of 0·00022N/m, and it may therefore be concluded that the H_{01}-wave attenuation is unlikely to be greatly affected by the imperfections in a well-laid waveguide. The practical attenuation is consequently determined largely by the minimum tolerable increase resulting from the use of a special waveguide structure.

TABLE 2
Mean Power Coupling Coefficients

MODE	IMPERFECTION	R.M.S. TOLERANCE	l (m)	w (per metre)
H_{02}, H_{03}	Gradual changes in diameter	$\psi = 5\times10^{-6}$rad	4	$3{\cdot}2\times10^{-9}$ $1{\cdot}4\times10^{-10}$
H_{02}, H_{03}	Diameter steps	$\frac{\delta s}{s} = 0{\cdot}0005$	4	$1{\cdot}5\times10^{-7}$ $4{\cdot}8\times10^{-8}$
H_{11}	Bow in sections	$C = 0{\cdot}0006\text{m}^{-1}$	2	$5{\cdot}2\times10^{-8}$
	Tilts	$\phi = 0{\cdot}0008$rad	4	$2{\cdot}6\times10^{-6}$
	Offsets	$\frac{d}{s} = 0{\cdot}0005$	4	$9{\cdot}7\times10^{-8}$
	Long bends	$C = 0{\cdot}0002\text{m}^{-1}$	1 000	$1{\cdot}2\times10^{-11}$ $(w' = 5{\cdot}0\times10^{-8})$
H_{12}	Bow in sections	$C = 0{\cdot}0006\text{m}^{-1}$	2	$1{\cdot}2\times10^{-6}$
	Tilts	$\phi = 0{\cdot}0008$rad	4	$9{\cdot}7\times10^{-6}$
	Offsets	$\frac{d}{s} = 0{\cdot}0005$	4	$5{\cdot}5\times10^{-7}$
	Long bends	$C = 0{\cdot}0002\text{m}^{-1}$	1 000	$2{\cdot}7\times10^{-11}$ $(w' = 1{\cdot}2\times10^{-7})$
H_{21}	Ellipticity	$\epsilon = 0{\cdot}0002$	1	$3{\cdot}6\times10^{-6}$
E_{11}	Bow in sections	$C = 0{\cdot}0006\text{m}^{-1}$	2	$8{\cdot}6\times10^{-6}$
	Tilts	$\phi = 0{\cdot}0008$rad	4	$3{\cdot}8\times10^{-6}$
	Long bends	$C = 0{\cdot}0002\text{m}^{-1}$	1 000	$1{\cdot}9\times10^{-9}$ $(w' = 6{\cdot}1\times10^{-7})$
Total power loss per unit length taking w' where $w \neq w'$				$3{\cdot}2\times10^{-5}$

* *Dielectric lined, as already noted.*

Parallel-Flow and Echo-Signals

Echo-signals in f.m. transmission systems produce distortion of the modulation, and with multi-channel telephony signals this results in intermodulation noise. The level of intermodulation noise is a function of the magnitude and delay of an echo signal, and it is possible to compute the distortion arising from a single echo[14,15]. In the case of circular waveguide transmission, however, the far-end signal will contain a large number of echoes of different magnitudes and delays, due to parallel-flow and reflections. The problem at hand is to calculate approximately the noise power ratio resulting after transmission through a long waveguide of a f.m. signal in which the multi-channel signal is simulated by random noise. Only an approximate solution is required initially, based on the estimated statistical departures from uniformity of the waveguide. The nature of the problem is such that a simple estimate, even to within a few orders of magnitude, cannot readily be made.

Echoes due to parallel-flow, arising from mode conversion and reconversion, are first examined. The n.p.r. with given modulation characteristics is dependent on the waveguide discontinuities and imperfections, and on the differential propagation constants of the relevant parasitic modes relative to the H_{01}-mode. The differential propagation constants are determined by the particular waveguide structure used, and it is one of the objects of the analysis to indicate what are satisfactory waveguide characteristics. An approximate solution to the parallel-flow problem is

* *In plain copper waveguide, with conductivity of $5{\cdot}8\times10^7$ mho-m.*

obtained, but a more rigorous treatment, requiring evaluation by a digital computer, is described in Appendix (4).

Echo-signals due to H_{01}-wave reflections, which are of less importance, are then treated. An approximate solution, based on that obtained for the parallel-flow problem, is adequate in this case.

In considering both parallel-flow and reflections, a long waveguide with a random distribution of irregularities is again assumed. It is further assumed that the total parallel-

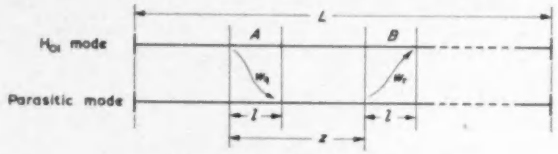


Fig. 1. Parallel flow generation

flow (including echo-signals) is very small—a necessary prerequisite to obtaining an adequate n.p.r. This assumption enables the multiple echoes constituting the parallel-flow signal to be treated as though echoes of different delay gave rise to mean intermodulation noise powers that can be added. This result may be derived for short delay echoes from the work of Bennett, Curtis and Rice[15] and has been confirmed by experiment. It has also been found experimentally that this result is valid for relative echo powers not exceeding about −20dB when the delay parameters, θ, is as large as 3π. When θ is very large, it may be shown[16] that the assumption is still valid, provided the echo power is small.

Parallel-Flow

The H_{01} mode is regarded as a transmission line having random coupling, in the manner assumed, to a second line representing a given parasitic mode. Any two sections, l, spaced a distance z apart, are shown in Fig. 1. Power is assumed to couple into the parasitic mode at A with a normalized value w_q per unit length, and back into the H_{01} mode at B with a normalized value w_r per unit length. An echo of delay T_z is thereby produced, and.

$$T_z = az \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

where a is the group-delay per unit length of the parasitic mode considered relative to the H_{01} mode. There are many other pairs of sections in the waveguide giving rise to an echo of delay T_z, the total normalized echo power with this delay being:

$$\eta_z = l^2 \exp(-2\Delta_\alpha z) \sum_{q=1}^{N-\mu} w_q w_r$$

where Δ_α = relative attenuation coefficient of the parasitic mode considered,

N = total number of sections in the waveguide,

μ = number of sections in the length z,

$r = q + \mu$.

Since:

$$N - \mu = \frac{L - z}{l}$$

where L is the total length, and w_q, w_r are random, the echo power becomes:

$$\eta_z = w^2(L - z)\exp(-2\Delta_\alpha z)\,\delta z \quad \ldots\ldots\ldots \quad (7)$$

Here w is the mean normalized power coupling per unit length and δz has been written for l. The quantity η_z is the normalized parallel-flow power with a delay T_z at the end of the long waveguide. It may be noted that the attenuation coefficient of the H_{01} mode has been taken as zero in deriving equation (7), in which only the differential attenuation occurs. The echo power η_z is consequently the power as a fraction of the H_{01}-mode power at the end of the waveguide.

The normalized intermodulation noise power, W_D (i.e. the reciprocal of the n.p.r.) due to an echo in a f.m. system with a given noise loading is a function of the echo power and delay. Thus, for a single echo:

$$W_{Dz} = F(\eta_z, T_z) \quad \ldots\ldots\ldots\ldots\ldots \quad (8)$$

The function F can be expressed analytically only for some ranges of delay and only when the modulation index of the f.m. signal is either very small or large. Integral equations defining the maximum and minimum values of F have been evaluated by Medhurst[14] for a useful range of modulation indices. Mean noise power curves derived from the two sets given by Medhurst may be adequately matched by dividing the delay into three ranges. When the modulating signal is Gaussian noise with a uniform spectrum extending from zero to f_n, the function F then becomes, for the noise at the highest baseband frequency*.

$$\begin{aligned} F_1 &= \tfrac{1}{8} m^2 \eta_z \theta^4 && \theta < \theta < \theta_1 \\ F_2 &= bm^2 \eta_z \theta^4 \exp -k\theta && \\ & && \theta_1 < \theta < \theta_2 \\ F_3 &= h\eta_z && \theta > \theta_2 \end{aligned}$$
$$\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

The empirical constants b, k, h and the limits θ_1, θ_2 are given in Table 4 for four values of m.

Equations (6) and (7) define η_z in terms of T_z and hence of θ. Noting the initial assumption on the treatment of multiple echoes, the intermodulation noise produced by all the parallel-flow power associated with one parasitic mode may therefore be calculated by integration of equation (8) in the variable θ. Equations (6), (7) and (9) are required, and the following substitutions are convenient:

$$u = (1/2\pi f_n a) \quad \text{(hence } z = u\theta\text{)}$$
$$g = 2\Delta_\alpha u$$
$$g' = 2\Delta_\alpha u + k$$

W_D is then the sum of the following:

$$W_{D1} = \tfrac{1}{8} m^2 w^2 u \int_0^{\theta_1} \theta^4 (L - u\theta)\exp(-g\theta)\,d\theta \quad \ldots\ldots \quad (10a)$$

* *If pre-emphasis is applied to the baseband signal, the worst n.p.r. is no longer necessarily at the highest frequency, but it will not be worse than is derived here.*

TABLE 3

Mode Parameters in 2in Diameter Waveguide at 35Gc/s

MODE	H_{11}	H_{21}	E_{11}	H_{01}	H_{12}	H_{02}	H_{03}
PARAMETER							
χ_{mn}	1·81	3·05	3·83	3·83	5·33	7·02	10·17
β(rad/m)	730	723	717	717	703	679	614
$\triangle\beta$(rad/m)	13	6	0	0	−14	−38	−103
α (N/m)	0·0022	0·0040	0·0052	0·00022	0·00063	0·00078	0·0018
λ_g(m)	0·00861	0·00869	0·00876	0·00876	0·00894	0·00925	0·01022
λ_c(m)	0·0882	0·0523	0·0417	0·0417	0·0299	0·0227	0·0157

$$W_{D2} = bm^2w^2u\int_{\theta_1}^{\theta_2} \theta^4 (L - u\theta)\exp(-g'\theta)\,d\theta \quad \ldots\ldots \text{(10b)}$$

$$W_{D3} = hw^2u\int_{\theta_2}^{L/u} (L - u\theta)\exp(-g\theta)\,d\theta \quad \ldots\ldots\ldots \text{(10c)}$$

In long waveguide systems the second term in the parentheses in the integrals of equations (10) may be neglected; the solutions are then:

$$W_{D1} = \tfrac{1}{8}m^2w^2Lu\,[A_1(0) - A_1(\theta_1)\exp(-g\theta_1)] \quad \ldots\ldots \text{(11a)}$$

$$W_{D2} = bm^2w^2Lu\,[A_2(\theta_1)\exp(-g'\theta_1) - A_2(\theta_2)\exp(-g'\theta_2)] \quad \ldots\ldots\ldots\ldots \text{(11b)}$$

$$W_{D3} = (hw^2L/2\Delta\alpha)\exp(-g\theta_2) \quad \ldots\ldots\ldots\ldots\ldots \text{(11c)}$$

range of values with practical values of g, g' and θ. When the product $g\theta$ (or $g'\theta$) is very small, evaluation is facilitated by the following series approximation:

$$A(\theta)\,e^{-g\theta} = (24/g^5) - \sum_{r=0}^{\infty}(-1)^r g^r\theta^{r+5}\left[\frac{1}{(r+1)!} - \frac{4}{(r+2)!} + \frac{12}{(r+3)!} - \frac{24}{(r+4)!} + \frac{24}{(r+5)!}\right]$$

The parameter u is inversely proportional to a, which is the differential group-delay per unit length between the wanted and parasitic modes. In highly overmoded waveguide:

$$a = (\Delta\beta/v_o\beta_{o1})$$

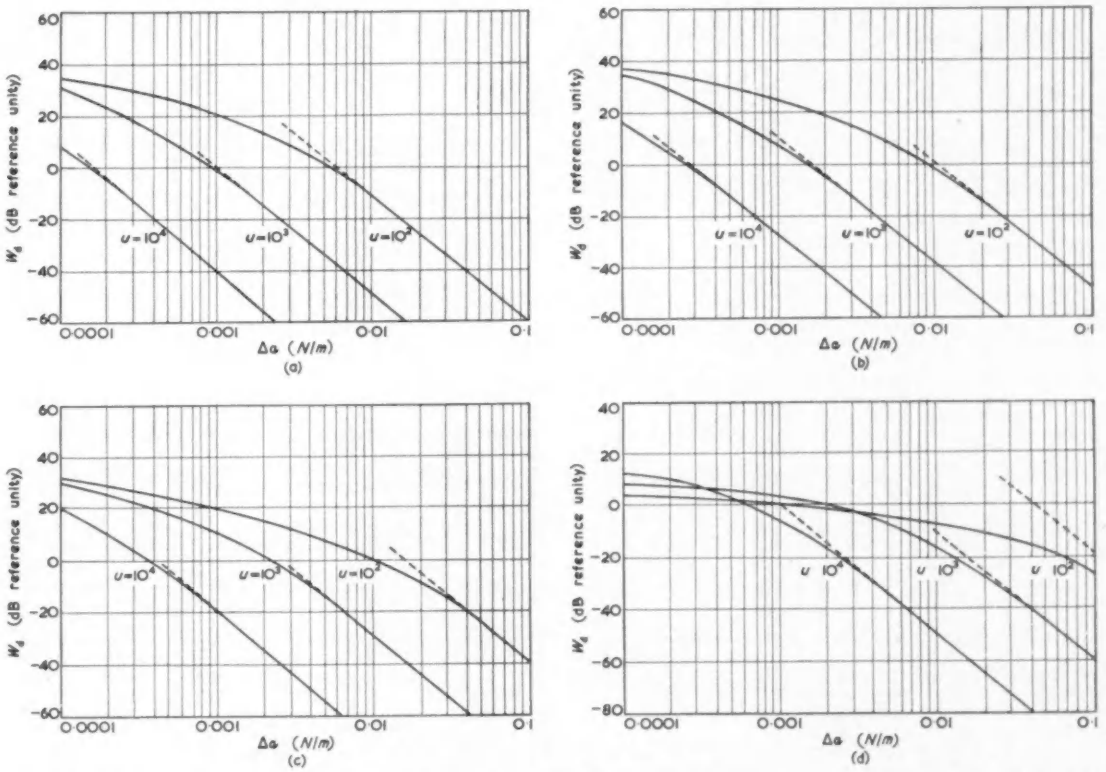


Fig. 2. Normalized intermodulation noise power per unit length for unit w, over the range $\Delta\alpha$=0·0001 Neper/m to 0·1 Neper/m, and for 3 values of u
Dashed lines show asymptotic form
(a) for m = 0·1, (b) for m = 0·4, (c) for m = 1·0, (d) for m = 10

where:

$$A_1(\theta) = (\theta^4/g) + (4\theta^3/g^2) + (12\theta^2/g^3) + (24\theta/g^4) + (24/g^5)$$

and $A_2(\theta)$ is the same with g' in place of g. The intermodulation noise W_{D1} is due to short-delay echoes, W_{D3} to those of long delay. The expressions can have a very wide

TABLE 4
Empirical Curve-Matching Constants

m	θ_1 (rad)	θ_2 (rad)	h	b	k
0·1	3	12	0·5	0·4	0·58
0·4	1	5	0·8	0·2	0·58
1·0	0·4	2	0·2	0·2	1·4
10	0·1	1	4×10^{-4}	0·3	11

where v_o = velocity of light,

β_{o1} = phase-change coefficient of the H_{01} mode.

Hence:

$$u = \frac{v_o\beta_{o1}}{2\pi f_n\Delta\beta} \quad \ldots\ldots\ldots\ldots\ldots \text{(12)}$$

Equations (11) have been evaluated for unit power transfer coefficient ($w = 1$) and unit waveguide length ($L = 1$); the results are shown in Fig. 2, in which the normalized intermodulation noise power, W_d, is plotted against $\Delta\alpha$ for four values of u and four values of m. Over this range, the intermodulation noise is less the larger $\Delta\alpha$ and u: however, u can be increased in a system only by decreasing $\Delta\beta$ and this in some cases (see equation (4)) increases w. In seeking to reduce intermodulation noise, it is therefore

desirable to design the waveguide so as to increase $\Delta\alpha$ only.

In Fig. 3, the relationship between W_d and the r.m.s. modulation index, m, is shown for four values of $\Delta\alpha$ and u. It may be seen that when $\Delta\alpha$ is very small W_d at first increases, but subsequently falls, with increasing m. This implies that the intermodulation noise derives mainly from long-delay parallel-flow power[16], and it is then clearly advantageous to operate with a large modulation index. On the other hand, when $\Delta\alpha$ is not very small, intermodulation due to short-delay parallel-flow power predominates, and W_d always increases with m. The complexity of the design problem is illustrated by the curves in Figs 2 and 3. The

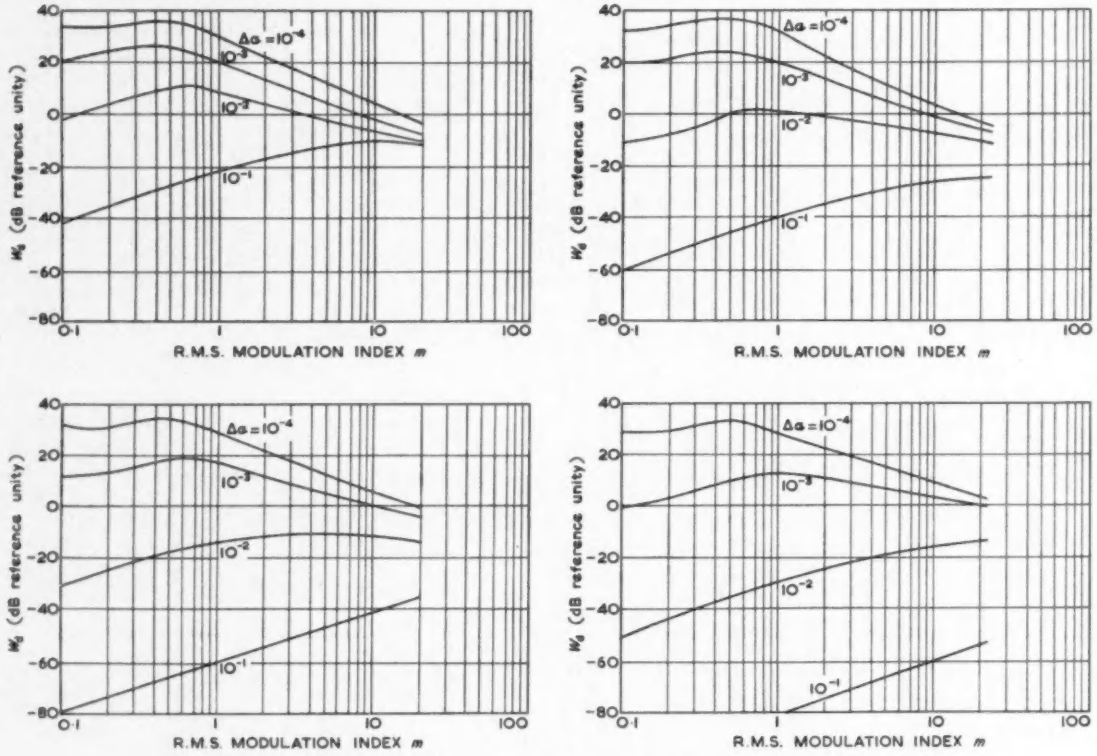


Fig. 3. Normalized intermodulation noise power per unit length for unit w, over the range m = 0·1 to 20.
(a) for u = 30, (b) for u = 100, (c) for u = 300, (d) for u = 1 000

optimum modulation index, for example, is different for each parasitic mode considered, and the overall optimum is dependent on the choice of waveguide structure, which determines the values of u and $\Delta\alpha$ for each mode.

When g (or g') is very large, the asymptotic form of the curves in Figs. 2 and 3 is given by the following:

$$W_d = \frac{3m^2}{32\Delta\alpha^5 u^4}$$

ECHO-SIGNALS

Echo-signals arise from reflections at the waveguide terminals and at discontinuities at the joints. Over long distances the echo-signals are highly attenuated relative to the wanted signal, so the terminal reflections may be neglected if moderately good matching is assumed. Provided the reflections at the joints are assumed to be random, a similar analysis may be used as for the parallel-flow problem.

Referring to Fig. 4, the total echo power, η_z, of delay T_z, due to the first echo in the length z (subsequent echoes are negligible in practice) is:

$$\eta_z = \exp(-4\alpha_{01}z)\sum_{q=1}^{N-1}\rho_q^2\rho_r^2$$

where α_{01} = attenuation coefficient of H_{01} mode,

ρ_q, ρ_r = reflection coefficients at q^{th} and r^{th} joints.

The delay is:

$$T_z = a'z$$

where $a' = 2/v_g$

v_g = group velocity of the H_{01} wave.

Following the previous method, and again utilizing the empirical functions F_1, F_2, F_3, the following approximate result is obtained for a very long waveguide:

$$W_{D1} = (L/8l)\, m^2\rho_{rms}^4 u'[A_1(0) - A_1(\theta_1)\exp(-y\theta_1)] \quad \ldots \quad (13a)$$

$$W_{D2} = (L/l)\, bm^2\rho_{rms}^4 u'\,[A_2(\theta_1)\exp(-y'\theta_1) - A_2(\theta_2)\exp(-y'\theta_2)] \quad \ldots\ldots\ldots \quad (13b)$$

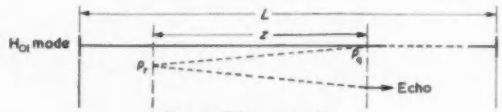


Fig. 4. Echo generation

$$W_{D3} = \frac{h\rho_{rms}^4 L}{4\alpha_{01}l}\exp(-y\theta_2) \quad \ldots\ldots\ldots \quad (13c)$$

where $y = 4\alpha_{01}u'$

$y' = 4\alpha_{01}u' + k$

This result is similar to that obtained for parallel-flow dis-

tortion, and may be shown in Figs. 2 and 3 after making the following substitutions:

$$\Delta\alpha \rightarrow 2\alpha_{01}$$
$$u \rightarrow u'$$

and noting that:

$$u' = (1/2\pi f_n a')$$

In 2in diameter copper waveguide in its final modified form, at 35Gc/s, α_{01} is about 0·0003N/m and v_g is $2{\cdot}93 \times 10^8$m/sec. The normalized intermodulation noise power, W_d, (unit ρ_{rms} and L/l) for this case is lowest when the modulation index is large, but even with an index less than unity, W_d is unlikely to exceed about 400 (26dB). If the r.m.s. diameter step is assumed to be as in Table 2, the r.m.s. reflection coefficient, which is approximately $0{\cdot}02\,\delta s/s$, is $1{\cdot}1 \times 10^{-5}$. With this value and:

$L = 280$km*,
$l = 4$m,
$f_n = 12{\cdot}5$Mc/s,

the n.p.r. in the highest channel of a 2 700-channel system would be about 120dB. It may consequently be concluded that reflections at joints in a well-laid waveguide are unlikely to be a limitation in f.m. transmission.

* *A standard sub-division of the C.C.I.T.T. hypothetical reference circuit.*

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(To be continued)

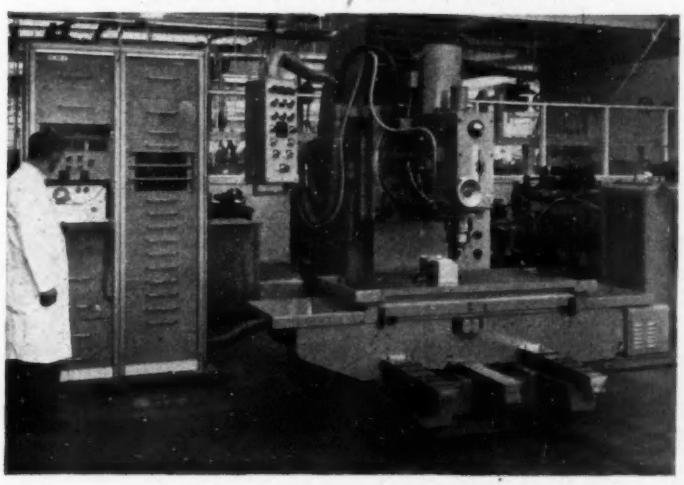
A Machine Tool Control System

A vertical milling machine made by Droop and Rein of West Germany has recently been fitted with a new system of numerical control by E.M.I. Electronics Ltd.

The machine is a general purpose one having a wide range of controlled movements and is particularly suitable for large die sinking. It is equipped with electrical servo drives and measuring units in the three axis—table, bed and head-stock.

The EMICON system of numerical control contains an angle safety unit which can be incorporated in all the controlled contour cutting machines which include the facility for compensating for a cutter of different size from that for which the programme was made. The safety unit derives its control information from the built-in computer that controls the machine. Since, however, it continually has access to the computer output before it is actually used to control the machine, it is able to predict a fault and stop the machine before the machine follows the mistake.

The Droop and Rein vertical milling machine fitted with the EMICON numerical tape control system. The control system is housed in the two racks to the left of the machine



In the tape system of machine tool control, co-ordinates of suitable points on the contour to be cut are considered by the programmer in groups of three consecutive points known as spans, which do not overlap but have common end points.

The equipment interpolates a smooth parabola passing through each group of three points calculated by the programmer. Many contours are smooth throughout and thus consecutive parabolic spans are arranged by the programmer to blend tangentially into each other.

If one of the three points forming a particular parabolic span does not lie on the smooth contour, the junction between adjacent spans becomes a sharp corner whose contained angle depends on the degree of offset of the point which is not on the contour and which, therefore, is causing the corner.

In this equipment, there exists a rotary device on the resolver, the angle of whose shaft is continually indicating the angle of the surface of the contour at the point being cut. It does this by sampling the commanded displacement of each axis over a very short length of time. Samples are continuously being taken of how much the machine has just been instructed to move and of its future movements.

If, therefore, the angle of the surface changes suddenly by more than a preset amount due to an offset point, the advance information sample immediately detects the transient and trips the safety circuits.

Under these conditions the machine stops before the error has affected the work-piece thus eliminating scrap. The error can then be corrected and the machine allowed to proceed.

When the programmer wishes to insert a sharp corner, he must also insert a corner code in the programme at that point. This is used by the equipment to inhibit the safety unit.

The EMICON system fitted to this machine provides several other facilities. It gives continuous contour control in any two axes and very fine step control with controlled feed speed in the third dimension. This speed can be independently set for 'in' and 'out' movements. A fully three-dimensional control system can be fitted to the machine if required.

The system also provides zero shifts in all axes, which facilitates accurate positioning of the work-piece, considerably reducing the setting-up time. The input programme can be corrected for the actual size of the cutter in use, even after a regrinding operation during the course of cutting a work-piece.

The Choice and Design of D.C. Convertors

By J. S. Bell†, A.M.I.E.E., A.M.Brit.I.R.E., A.F.R.Ae.S., and P. G. Wright*.

The design of single and two transformer convertors is discussed and their performances compared. Design steps are indicated and two practical designs are worked out as examples.

(Voir page 265 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 272)

DURING the course of general work upon airborne navigational aids it became necessary to investigate the design of self-excited convertors to provide high voltage d.c. supplies from a low voltage source. Output powers up to 120W were required and the designs were to incorporate transistors and diodes in current production. The devices considered were also likely to be used to supply 'square wave a.c.' for certain types of motors at similar powers.

The initial designs considered were based upon work by Light and Hooker[1] and also Uchrin and Taylor[2] using OC28 transistors and a single large saturating transformer. It was found practicable to obtain an output of 55W at 78 per cent efficiency using the circuit shown in Fig. 3. However, as discussed later in this article, the circuit had several limitations and a further design using a large non-saturating output transformer and a small saturating oscillator transformer[3] was considered. Outputs of up to 140W were obtained without difficulty, the efficiency being from 75 to 88 per cent depending upon load.

The general design philosophy is studied in some detail and includes such items as frequency, choice of transistors, choice of cores, transformer windings and biasing. Two design examples are worked out in the text, an example of each type of convertor discussed being considered. Brief details of suitable measuring techniques are also presented. It was felt that details of rectifying techniques were beyond the scope of this article.

General Design Discussion

The convertor can be designed with one or two transformers. The single transformer design has the following disadvantages:

(a) As the transformer saturates twice in each cycle the core losses may be considerable, particularly if the operating frequency is higher than 1kc/s.

(b) Since the switching operation is brought about by the saturation of the core at the end of the conduction half-cycle of each transistor, a sudden rise in collector current will occur at this point, regardless of the load.

(c) In order to obtain clean switching of the transistors it is desirable to use (more expensive) high quality core material in toroidal construction.

(d) The frequency of operation varies with load and a change in frequency of 20 per cent from no load to full load is typical.

For many purposes the disadvantages given above are not unacceptable, particularly when the size of the unit is required to be smaller than the more sophisticated two transformer system. Furthermore the single transformer unit is rather easier to design.

The two transformer method has an inherently higher efficiency as only the oscillator transformer saturates. In addition, as the output transformer does not saturate there is no high collector current spike at the end of each conducting half cycle and much higher powers may be supplied. The frequency is almost independent of load, the slight drop on load amounting to only a few per cent.

Either design may adopt the common base, common collector or common emitter configurations with either npn or pnp germanium power transistors. Results with silicon power transistors should be similar. In the latter case it would be reasonable to expect slightly lower efficiencies due to the higher collector saturation resistance of the silicon types at present available. Figs. 1, 2 and 3 illustrate the three basic configurations.

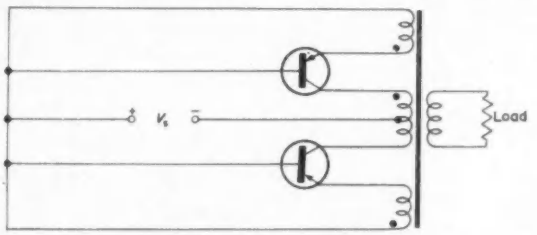


Fig. 1. Common base configuration

Oscillations in these circuits will not normally commence when the supply voltage is connected unless some bias is applied to one or both the bases. Once the oscillations have started, they will continue without the bias and thus arrangements are sometimes made to provide a momentary bias by the use of a starter button. This system suffers from the disadvantage that, in the event of an overload, oscillations may cease and a re-application of bias is then necessary. Although this arrangement implies a built-in safety factor it was considered essential for the application

Symbols

A	=	cross-sectional area of core (cm^2)
A'	=	cross-sectional area of core (m^2)
A''	=	winding area of toroidal core (in^2)
B_{sat}	=	saturation flux density (gauss)
B_{sat}'	=	saturation flux density (Wb/m^2)
Φ	=	flux (Wb)
n	=	ratio of primary winding to feedback winding
N	=	Number of turns on an inductor
N_p	=	Number of turns on transformer half primary
N_s	=	Number of turns on transformer secondary
R_b	=	total base resistance of a transistor (Ω)
V_s	=	supply voltage (V)
V_p	=	primary transformer voltage (V)
I_{co}	=	transistor leakage current (mA)
d	=	internal diameter of toroidal core (in)
β	=	large signal current gain of a transistor

† *Fairey Aviation of Australia Ltd, formerly with Smith's Aircraft Instruments Ltd.*

* *Smith's Aircraft Instruments Ltd.*

under investigation that the circuit should be self-starting at all times. Although this could be achieved by means of a simple relay connected across a rectified output connecting the bias whenever the oscillations ceased, permanent bias was adopted in all cases. The final arrangement is shown in Fig. 4, while a suggested method for biasing the common collector configuration is given in Fig. 5. Whatever the form of permanent biasing, it will consume some power, and so reduce the efficiency. It should be noted that the permanent bias voltage must not exceed the feedback voltage or the transistor will never be cut off during either half cycle.

An attraction of the common collector arrangement is that the transistors may be mounted on a common heat sink (in most cases) but self-starting on load is rather more difficult to attain than in the common emitter arrangement.

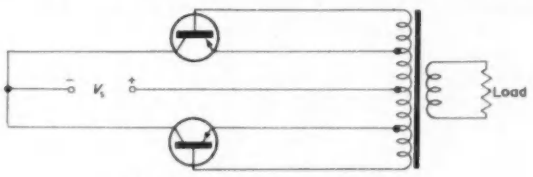


Fig. 2. Common collector configuration

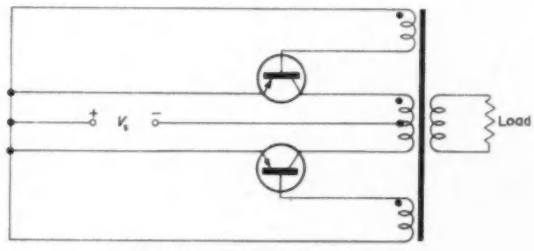


Fig. 3. Common emitter configuration

Theory

Single Transformer Convertor

The operation of the single transformer push-pull convertor is now widely known. It may be simply described as follows.

Consider the circuit illustrated in Fig. 3, with one transistor cut off and the other conducting. Almost the full supply voltage V_s will be applied across the transformer half primary, and the current (i) will rise linearly ($di/dt = V_s/L$) until the core begins to saturate. The primary inductance will then fall and the rate of change of current (di/dt) will increase rapidly until the current reaches a maximum value of βi_b determined by the drive current i_b available from the feedback winding, and the large signal current gain (β) of the transistor. The rate of change of current and hence the flux in the core becomes zero. At this point the feedback voltage will be zero, and the transistor collector current will cease. As this collector current falls to zero, flux is produced in the core in the opposite direction and the other transistor is switched on by the voltage induced in its feedback winding. The cut off transistor is further cut off by the reverse bias applied to its base.

If a voltage V volts is applied across an inductance having N turns, the rate of change of flux (Webers/second) is given by:

$$d\Phi/dt = V/N$$

(Where the permeability of the core is assumed constant to saturation.) As, in a convertor, there is a complete reversal of flux, then:

$$\int_0^t (V/N)\ .\ dt = 2\int_{-\Phi_{sat}}^{+\Phi_{sat}} d\Phi \quad \ldots\ldots\ldots (1)$$

thus:

$$t = \frac{4N\Phi_{sat}}{V}$$

$$f = \frac{V}{4N\Phi_{sat}}\ \text{c/s} \quad \ldots\ldots\ldots\ldots (2)$$

or in c.g.s. units:

$$f = \frac{V}{4NB_{sat}A}\ .\ 10^8 \quad \ldots\ldots\ldots\ldots (3)$$

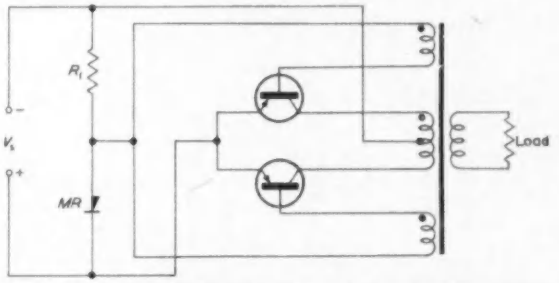


Fig. 4. Common emitter configuration with starting arrangement

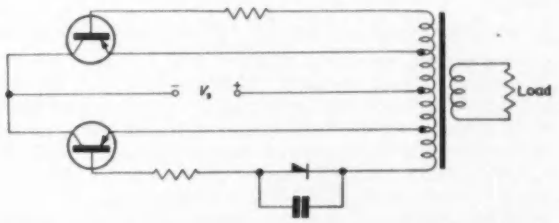


Fig. 5. Suggested starting arrangement for common collector configuration

In addition to this triangular magnetizing component of primary current, there will be a rectangular component due to the resistive load on the transformer secondary and the slight loading imposed by the feedback winding.

Two Transformer Convertor

In this case, where a non-saturating output transformer is used, the operation is rather different. A basic circuit is given in Fig. 6. If one transistor is considered as switched on it can be seen that the magnetizing current to T_1 will flow via the feedback resistor R and half the primary winding of T_2. This current will rise exponentially until the core of T_1 begins to saturate. The inductance, and hence the impedance of T_1 primary then falls, and more of the supply voltage appears across R and T_2 until the voltage across T_1 becomes too small to drive the transistor base winding sufficiently. The collector current will fall, causing the flux in T_2 core to reverse. This reverses the voltage applied to T_1 primary and the voltages induced in the feedback windings will switch the transistors over. The half cycle then repeats itself.

The expression for the frequency of oscillation will not be the same as for the single transformer case. In addition to the terms involved in equation (2), the frequency is dependent upon the inductance of the output transformer

primary, the value of the feedback resistor and the drive required by the transistor bases. As would be expected, increasing the value of feedback resistor decreases the frequency. If the base drive is reduced, (i.e. the base impedance increased or feedback turns reduced), the frequency will increase. An empirical formula for frequency is given in the design procedure.

Determination of Value of Biasing Resistor

The method outlined below by Stephenson[5] may be used to determine the value of R_1 in Fig. 4.

Oscillation will not commence until the loop gain of the system exceeds unity:

$$\text{i.e. } (g_m R_L)/n > 1$$

where R_L is effective resistive load across the primary

$n = N_p/N_f$ i.e. ratio of turns on transformer.

$$1/g_m = r_e + (R_b/\beta)$$

$$r_e = \frac{25}{I_e\,(\text{mA})}$$

Thus for starting:

$$\frac{R_L}{n[r_e + (R_b/\beta)]} > 1$$

Hence:

$$I_e > \frac{25\beta n}{\beta R_L - nR_b} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The base current may then be obtained and a value for R_1 selected.

Design

Design Procedure for a Single Transformer Convertor

Knowing the maximum power output required and the d.c. supply voltage available an overall efficiency for the convertor may be estimated (usually 75 to 85 per cent) from the frequency, type of transformer etc. The input power now being known, the maximum input current is quickly calculated and a transistor may be chosen which will handle this collector current. With its base open-circuit this transistor should have a collector-emitter breakdown voltage of at least twice the supply voltage.

The choice of frequency should now be decided upon and it may be necessary to avoid beat effects with other supplies. A typical value could be 700c/s. A core can be chosen and the primary winding calculated using equation (2). The base-emitter voltage required to drive the transistor to the maximum collector current demanded should then be ascertained from the transistor data. Allowing for the forward voltage drop across the starting diode (or resistor) if included, the voltage required from the transformer winding, and hence the turns ratio n may be determined. About 5 per cent additional turns should be included in order to compensate for voltage drops. It should be noted that the voltage is of square waveform, hence $V_{rms} = V_{peak}$. It is sometimes found that the winding area is insufficient and thus obviously a larger size core must be chosen and the calculations repeated.

Design Procedure for a Two Transformer Convertor

As before, the input power is calculated and a suitable transistor chosen. A small core is selected for the oscillator transformer and the approximate number of primary turns is calculated by using the empirical relationship.

$$\text{Primary turns} = \frac{V_s}{8fB_{sat}'A'} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

A slight readjustment may be required here later if the frequency desired is to be within close limits. The feedback turns may be calculated as in the previous case except that the whole of the collector-collector voltage does not appear across the primary winding, some of the voltage being dropped across the resistor R. It has been found satisfactory for the calculations that follow, to assume that voltage V_s is applied across the full primary.

The design of the output transformer, being non-saturating, follows normal procedure. A value of starting resistor may be obtained using equation (4).

The feedback resistor R, which is normally several hundred ohms, should be large enough to eliminate the current spike in the transistors, yet small enough to allow sufficient drive to the base circuit.

Frequency of Operation

The frequency of operation affects the efficiency of the convertor in a number of ways. A low frequency will result

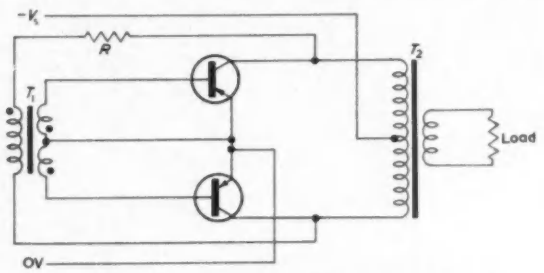


Fig. 6. Basic circuit of two-transformer convertor

in low core losses in the transformers, but will entail large numbers of turns, and hence large copper losses. A high frequency has the opposite effect and allows the transformers to be kept physically small. Unless the frequency is dictated by outside requirements the actual frequency chosen will depend mainly on the output power required. Generally speaking, the higher the power, the lower the frequency for maximum efficiency.

Choice of Transistor

As previously mentioned the transistor is selected for its ability to carry the required collector current and for its collector-emitter breakdown voltage with the base open-circuit. It is frequently necessary to consider the power dissipated in the transistor for the following reasons.

(1) The switching times are not infinitely small, and during the switching operation, collector-emitter current and voltage exist together.

(2) When the transistor is cut off, it is subjected to twice the supply voltage and leakage current I_{co} will flow. Hence the power dissipated will rise with temperature due to increase in I_{co}.

(3) When the transistor is bottomed, there is still a small voltage developed across it due to the collector saturation resistance. This effect is more pronounced in silicon transistors.

(4) Hole storage effects cause currents to flow at the beginning of the cut-off half cycle.

In general, the total transistor power dissipation will not normally be serious except at ambient temperatures above 40°C where a heat sink may be necessary.

Choice of Transformer Cores

Oscillator Transformer

High saturation flux density, high permeability up to

saturation and low hysteresis loss are desirable properties of the core material. One material satisfying these conditions reasonably well is HCR but, although not normally serious, its permeability is affected by both temperature and pressure. A nickel iron core is almost essential for power convertors because with the high saturation flux densities obtained the transformer may be kept reasonably small. For very low powers a mumetal or ferrite core could be used, a high operating frequency being chosen. The circuits will operate satisfactorily with materials not having a sharp saturation point. Examples are Trancor, Radiometal, and Alphasil. The efficiency will be reduced and the frequency of operation may require adjustment by experiment.

Output Transformer (Two Transformer Convertor)

Since this is purely an output transformer, and should not saturate, the choice of core material is wide. If small size is of prime importance, as is often the case in airborne equipment, then high saturation flux density will be a most important factor. If maximum efficiency is desired, then high permeability and low incremental hysteresis loss will be required.

TRANSFORMER WINDINGS

The leakage inductance of the transformers should be as low as possible in order that the transistors may switch cleanly. Strip wound toroidal cores can give excellent results, but are not essential (particularly in the two transformer case). It is important, however, that the primary winding of the output transformer is bifilar wound to reduce the leakage inductance.

In certain specialized applications, for example the provisioning of two or more stacked supplies such as are common in d.c. amplifier configurations it is often difficult to arrange a suitable earth connexion. It is thus possible, even with bifilar windings, to obtain a spiky waveform with the possibility of catastrophic failure of the transistors. Experience has indicated that this may be avoided by incorporting in the transformer(s) electrostatic screen(s) suitably earthed.

BIASING

Although an approximation may be made for the value of the biasing resistor, the actual value is best determined by trial, the highest value being chosen which will ensure reliable starting on full load. If the convertor is working into a capacitive load such as a rectifier and smoothing capacitor, the initial load presented at the transformer primary is greater than the running load, and the starting resistor will need to be considerably lower than its calculated value.

SUPPLY IMPEDANCE

It is important that the impedance of the source should be low; this may call for connexion of a large capacitor directly across the convertor input. The low impedance is essential to obtain the sharp front of the square wave.

Practical Design Examples

SINGLE TRANSFORMER CONVERTOR (DESIGN 'A')

Specification

The following specification is given:

Output required: 300V at 60mA
Supply : 24V
Frequency : 700c/s (approx)

General Design

A single transformer convertor will fulfil these requirements adequately. The design procedure follows.

Maximum power out = $300 \times 0{\cdot}06 = 18$W

Assuming an efficiency of 75 per cent

The maximum input current = 1A.

A Newmarket V60/30P transistor is suitable. For the transformer, a Trancor toroidal core was considered with a cross-sectional area of 0·58cm² and B_{sat}' of 1·6Wb/m² (16 000 gauss). Substituting in equation (2):

$N_p = 92$ turns.

Now for a peak current of 1A, 22 s.w.g. enamelled wire is suitable, that is complete primary winding is 92 + 92 turns of 22 s.w.g.

Winding area available on the core is given by:

$$A'' = (\pi d^2/4) - \frac{\pi(\text{winding machine shuttle dia})^2}{4}$$

$$A'' = (1{\cdot}1^2\pi/4) - \frac{0{\cdot}375^2\pi}{4}$$

$$= 0{\cdot}84\text{in}^2.$$

This area will accommodate 500 turns of 22 s.w.g., thus the 184 turns on the primary are easily accommodated.

Feedback Winding

For a V60/30P transistor a base-emitter voltage (V_{be}) of 750mV will be required to drive the collector current to 1A. As the voltage drop across the starting diode is approximately 900mV, the voltage required from the feedback winding is 1·65V.

$$\therefore\ N_F = N_p(1{\cdot}65/24)$$

$$= 6{\cdot}9 \text{ turns.}$$

The next highest integer, seven in this case, is selected. The base current will be approximately 70mA in the worst case, thus the feedback winding will be 7 + 7 turns of 36 s.w.g.

Secondary Winding

Approximating for losses:

$$N_s = (V_s/V_p)\ .\ N_p \times (100/95) \quad \ldots\ldots\ldots\ (6)$$

$$= \frac{300 \times 92 \times 100}{24 \times 95}$$

$$= 1\,200 \text{ turns.}$$

The maximum current expected is 60mA so the secondary winding may comprise of 1 200 turns, 36 s.w.g. enamelled wire, interleaved at each 300 turns with a suitable form of insulation.

Biasing

In order to calculate the value of biasing resistor it is only necessary to substitute in equation (4).

Where $\beta_{min} = 15$; $R_L = 32\Omega$

$n = 13$; $R_b = 20\Omega$

$$I_c > \frac{25 \times 15 \times 13}{(15 \times 32) - (13 \times 20)}$$

$$I_c > 22\text{mA}$$

Thus total base current required $\frac{2 \times 22}{\beta}$ mA = 3mA

Hence $R = 8\text{k}\Omega$.

The final circuit is given in Fig. 7.

Two Transformer Convertor (Design 'B')

Specification

Supply voltage: 28V

Frequency: 700c/s

Output required: 320V at 125 + 75mA

The frequency should be reasonably stable with wide variations in load.

General Design

The total output required is 64W and as there is to be a wide variation in load this leads to the choice of a two transformer device.

Assuming an efficiency of 80 per cent the input power required will be 80W, that is an input current of 2·85A is required. A Mullard OC28 transistor was selected as being suitable; this has a minimum β of approximately 30 at 3A.

Oscillator Transformer

As this convertor was required for an airborne installation where weight and physical size must be kept to a

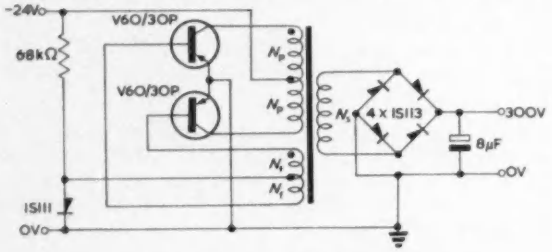


Fig. 7. Arrangement of practical design 'A'

minimum a small toroidal core of Trancor material was chosen having a core area of 0·201cm² and a saturation flux density of 1·35Wb/m² (13 500 gauss).

Substituting in equation (5):

Primary turns = 185 turns

Feedback Winding

Approximately 600mV base to emitter voltage is required by an OC28 to give a collector current of 3A. Taking the forward voltage drop across the starting diode to be 900mV a voltage of 1·5V is required from the feedback winding.

Now:

$$N_f/N_p = V_f/V_s$$

whence N_f = 10 turns.

Assuming an average β of 30

I_b maximum = 100mA

i.e. feedback winding becomes 10 + 10 turns of 36 s.w.g.

From the above it was estimated that 6·5mA maximum flows in the primary, hence a practical primary winding would consist of 185 turns of 42 s.w.g.

Output Transformer

For the application in question it was thought suitable to operate a stack of three Trancor toroidal cores at 400mV/turn for the complete stack. The same individual dimension of core as used for the oscillator transformer in design 'A' was chosen.

Thus $N_p = 28/0{\cdot}4$

$= 70$ turns

With a peak current of 2·85A the primary winding will consist of 70 + 70 turns of 20 s.w.g. wire. From published data for toroidal windings the above primary will occupy 45 per cent of the available space. This is acceptable.

The secondary windings are quickly calculated from:

$$N_s/N_p = V_s/V_p \times (100/95)$$

This gives 824 turns for each of the two windings required. The first winding for 125mA would normally be wound with 34 s.w.g. and the second one which carries 75mA with 36 s.w.g.

Feedback Resistor

A value of 560Ω was chosen and this later proved suitable in practice. A fairly wide variation from this chosen value would generally be acceptable.

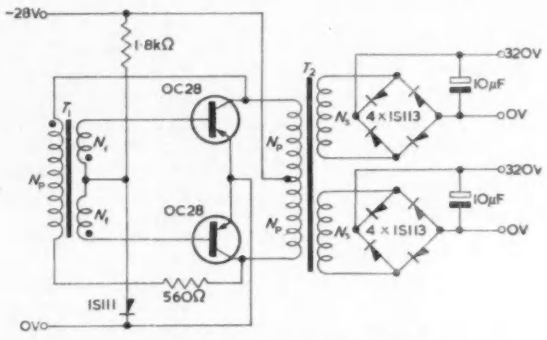


Fig. 8. Arrangement of practical design example 'B'

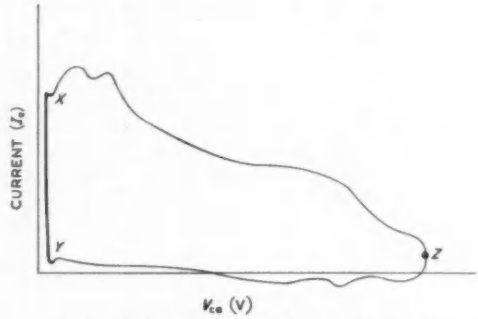


Fig. 9. Duty cycle of transistor in design 'B'

Bias Resistor

$$n = N_p/N_f = (185/2)/10$$

Thus $n \simeq 9$

Now taking $\beta = 30$, $R_L = 11\Omega$ and the input resistance of an OC28 transistor at low currents to be about 30Ω, from equation (4):

$$I_c > 110\text{mA}$$

$$\therefore I_b \simeq 7\text{mA}$$

$$\text{Thus } R = \frac{28}{7 \times 10^{+3}}$$

$$= 4\text{k}\Omega$$

In practice, this value can only be approximate as β and the input resistance of the transistor can vary widely from sample to sample. Furthermore R_L is not truly resistive. Generally, providing that there is not an undesirable power loss it is good policy to reduce this value of R; in the example under consideration a value of 1·8kΩ was selected.

Final Adjustments and Tests

The frequency of operation was a little high and the primary turns in the oscillator transformer were increased to 210. The feedback turns were increased in proportion.

The circuit illustrated in Fig. 8 operated satisfactorily on 100 per cent overload, in fact an output of 170W was obtained. It was interesting to note that self-starting at this value of load by suitable choice of biasing resistor was possible, although the current drain down the biasing chain became rather high.

Waveforms and Measurements

The current pulse through the transistors discussed may be examined by inserting a small resistance (a fraction of an ohm) in each emitter lead and displaying the voltage across it on an oscilloscope. Collector voltages in such applications may be misleading.

A good indication of the operation of the transistor may be obtained by displaying emitter current against collector-emitter voltage. Fig. 9 illustrates the trace obtained from the two transformer convertor. The brightest portions of the curve (at Z and between X and Y) indicate which parts of the cycle took up most of the periodic time. The switching transients are represented by the trace between X and Z and between Y and Z.

Conclusion

Investigations have been carried out into the practical design of high power transistor convertors for airborne applications. The output is in the form of square waves, suitable if required, for rectification. Design steps have been presented and practical designs given, one of which will supply up to 140W output at efficiencies of up to 85 per cent.

Acknowledgment

The authors wish to thank the Technical Director of Smith's Aircraft Instruments Ltd for his kind permission to publish this article and also Mr. N. L. Sigournay for his assistance in checking the original manuscript.

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Secondary Surveillance Radar

An experimental Secondary Surveillance Radar (s.s.r.) will be introduced shortly to serve the Southern Air Traffic Control Centre. This experimental service will, in due course, become part of the normal operational facilities of the Southern Centre and similar facilities will be deployed to cover other areas of the United Kingdom airspace.

During the experimental stage, aircraft wishing to use the s.s.r. service will need to carry a transponder capable of 2-pulse side-lobe suppression on Mode B in accordance with the provisions of Annex 10 to the ICAO Convention. United Kingdom ground interrogators will be capable of operating on Mode A, as required by ICAO Annex 10, but the absence of side-lobe suppression facilities in aircraft transponders will prevent fully effective employment of the s.s.r. system and consequently civil aircraft will be required to respond on Mode B for the purposes of the trials.

When the service becomes operational it will be necessary for aircraft to carry a transponder in order to operate in certain areas of United Kingdom airspace above a minimum height which will be specified. Initially this minimum height may be of the order of 25 000ft but subsequently the level will be lowered progressively as and when ground and aircraft equipment programmes permit. Civil aircraft transponders will be required to provide 2-pulse side-lobe suppression facilities on Mode B in accordance with the provision of ICAO Annex 10, in addition to the minimum Mode A facility.

For operations within the United Kingdom, aircraft transponders should conform initially to the minimum performance characteristics set forth in 'Minimum Performance Required of Civil Transponder', published in January, 1961.

The United Kingdom will continue to adhere to the provisions of ICAO Annex 10. Ground interrogators will therefore be capable of interrogation both on Mode A and on Mode B. However, Mode B will be used to provide a clear channel for close control of designated civil traffic.

It has long been the United Kingdom view that side-lobe suppression facilities are essential for the safe and efficient employment of Secondary Surveillance Radar. Consequently the United Kingdom Ministry of Aviation supports the United States Federal Aviation Agency proposal for the international incorporation of side-lobe suppression facilities on Mode A. To this end the Ministry of Aviation has co-operated in the preparation of 'System Characteristics, Application Standards and Guidance Material' published in December, 1960, which sets out proposals for the incorporation in Annex 10, of a 3-pulse side-lobe suppression system developed by the Federal Aviation Agency, in addition to the existing ICAO 2-pulse side-lobe suppression system. The United Kingdom Ministry of Aviation will support the submisson of these proposals to ICAO for consideration by Member States.

The Ministry of Aviation will take appropriate steps to ensure that ground interrogator facilities in the United Kingdom will be designed and operated in accordance with the provisions of Annex 10 as amended from time to time.

Television Installation at a Car Factory

Thirteen Marconi closed circuit television camera channels and associated equipment form an integral part of a new automatic routing system to facilitate the inspection of new car bodies at the Standard-Triumph Motor Company's Works at Coventry. The installation is claimed by Standard-Triumph to be unique and the most advanced in the world in terms of efficiency and rigidity of control.

The cars arrive on conveyor belts from the manufacturing areas into a new extension hall for further inspection. Each of the various types of vehicle is carried in a special skip which incorporates trip devices peculiar to the type it is intended to carry. These trips actuate routing mechanisms on the conveyor belt system to channel the vehicles to their correct destinations in the area auomatically. Here they undergo a series of stringent inspections after which the 'passes' are automatically delivered to other floors while any rejects are diverted along a rectification line for further work to be done on them.

The closed circuit television installation fulfils several functions in the routing and inspection processes, and for these the cameras are installed at strategic points within the area. At a central Control Room five Marconi 14in monitors provide pictures from five cameras mounted in various parts of the body storage area to enable controllers to identify the various types of car bodies passing along the conveyor belts and to keep the Programming Department constantly informed of the current position. Details of the colour and other relevant data are carried in code form on a card on each vehicle.

Any of the remaining eight cameras can be switched to the sixth picture monitor and this enables a controller to keep a close watch on the passage of vehicles at all stages of progress. He can ensure that no mishap occurs; he can check that the cars are moving along their programmed routes; he can foresee where bottlenecks are likely to occur and take steps to avoid them, and generally expedite the progress through the inspection area. The use of television thus enables all supervision to be carried out from a central point and removes the necessity for a man to be stationed at every point equipped with an open telephone line to the Programming Department.

The Marconi installation consists of 13 camera channels type BD871 and eight 14in picture monitors type BD879, together with ancillary equipment.

COLD-CATHODE TUBE CIRCUITS FOR AUTOMATION

By R. S. Sidorowicz*, A.M.I.E.E.

(Part 2)

(Voir page 196 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 203)

Counters

Cold-cathode tube counters can be divided into two groups: bistable circuits or binary counters and multi-stable circuits or chain counters. There exist at least four types of binary counters and many types of chain counters[2,3,6,7,11,12,15,17,20,21]. Most of these circuits have been described in various papers. However, two of the binary circuits and one standard chain counter will be mentioned, since they are used in a variety of derived circuits. Also these counters have proved very successful and are essential in the design of various control and automation systems.

A capacitance-anode-coupled binary circuit is shown in Fig. 11. Its operation is briefly as follows[2,14]. When the supply voltage is switched on, the trigger potential of V_1 momentarily rises to above 100V and so the tube is struck. If now a pulse is applied to the common input,

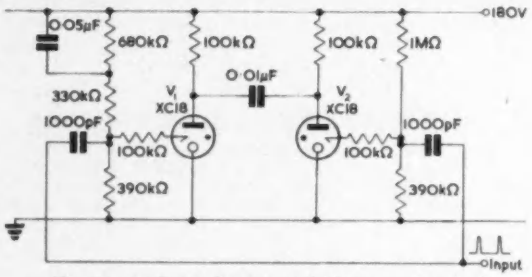


Fig. 11. Anode-capacitance-coupled binary counter circuit

V_2 will be ignited. The anode voltage of V_2 drops to about 70V, so that the anode potential of V_1 is temporarily reduced to below V_{sm} (maintaining voltage) and V_1 is extinguished. Application of another pulse to the input results in the re-ignition of V_1 and extinction of V_2. The circuit in the form shown in Fig. 11 is not suitable as a counter, since it has no convenient pulse output. However, it is a constituent element in a variety of circuits: univibrators (see Figs. 6, 7, 10), amplifiers (see Figs. 3 and 4), oscillators and gating circuits. It can also be used as a relay-drive circuit, if suitable modifications are introduced (see Fig. 8). An inverted version of the circuit is also known[3,11], in which the current limiting resistors and the coupling capacitor are connected in the cathodes, but this circuit is not widely used.

A resistance-anode-coupled bistable circuit is shown in Fig. 12. A detailed description and analysis of the circuit can be found elsewhere[3,7,11,18]. Normally, V_1 is conducting and its cathode potential is about 70V. When a positive pulse is applied to the common input, V_2 is ignited and V_1 is extinguished; an exponentially rising voltage step is therefore obtained at the cathode of V_2, while the voltage at the cathode of V_1 decays exponentially to zero. Application of the second pulse restores the circuit to its original state. This binary counter can be used for driving a relay, if a pair of XC23's are used instead of XC18's and the components are suitably adjusted. The relay should be connected in series with one of the cathode resistors. An inverted version of the circuit[11] is very useful in that it can be used in logic circuits, oscillators, univibrators (see Fig. 4) or as a pulse amplifier (see Fig. 5).

The circuit of Fig. 12 is inconvenient as a counter due to the fact that it does not produce a suitable output

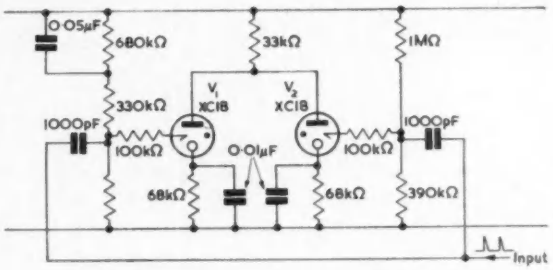


Fig. 12. Anode-resistance-coupled binary counter circuit

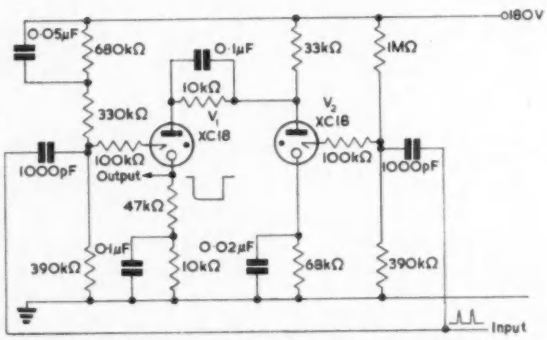


Fig. 13. Resistance-coupled binary counter with a pulse output

pulse. It was seen that a slowly rising waveform was obtained at the cathode of V_1. Though such a signal can be used to fire another binary counter, this is usually undesirable, since due to the 'slowness' of the signal, the instant of ignition of the triggered tube will be rather indefinite. This difficulty can be overcome by modifying the circuit. The resulting binary counter is shown in Fig. 13. The operation of this circuit is essentially similar to that of Fig. 12, except that a fast-rising edge having an amplitude of about 50V is obtained at the cathode of V_1, when V_1 is fired. This pulse output is suitable for pulsing another binary circuit. It will be seen later that the counter of Fig. 13 can have many other applications.

Probably the most popular chain counter is the resistance-anode-coupled circuit[2,6,7,8,13] shown in Fig. 14. Initially, only V_1 is conducting and the potential of its

* *Hivac Ltd.*

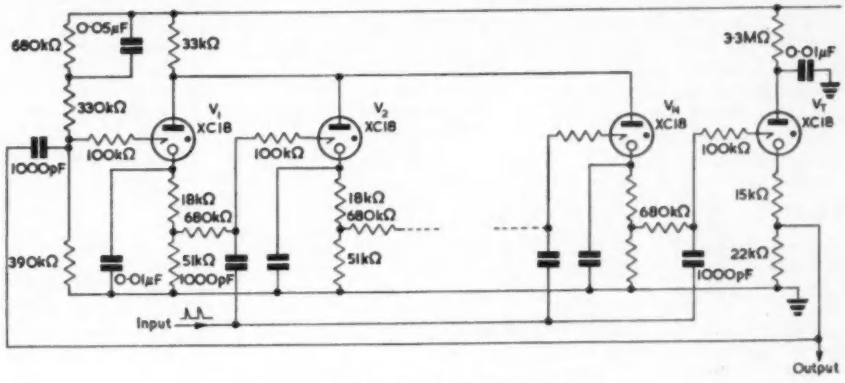


Fig. 14. Ring counter with a terminal stage

cathode is about 70V. A portion of this voltage (about 50V) is applied to the trigger of V_2 through the 680kΩ resistor. When a pulse of about 50V amplitude is applied to the common input, V_2 is ignited. This results in the momentary lowering of the common anode potential and extinction of V_1. The next pulse 'shifts the conduction' to V_3 and so on. After the application of $(N-1)$ pulses, V_N becomes ignited and the terminal tube V_T becomes biased. Consequently, the N^{th} pulse fires V_T which produced a pulse and re-ignites V_1. After N pulses the circuit is therefore returned to its zero position. The pulse from the terminal stage can be used to drive another counting chain.

With the values of the components indicated in Fig. 14, the maximum speed of the circuit will depend on the number of tubes in the chain. For $N=10$, the maximum pulsing rate will be about 100c/s. This is due to the fact that the operating speed of the terminal stage is limited to about 10c/s. If this is replaced by a faster amplifier (e.g., see the circuit of Fig. 3), the maximum rate will be about 500c/s.

By employing the coupling technique of Fig. 14, it is possible to build a bi-directional (or reversible) counter chain. The resulting circuit is given in Fig. 15. It is seen that the circuit is based on the double-trigger tube, type XC24. It may be mentioned however that each such tube can be replaced by a pair of triodes, type XC18, whose anodes (and also cathodes) are strapped together. Indeed, such an arrangement may be advantageous in that the ionic coupling existing between the two triggers in a double tube is avoided when two tubes are employed in the circuit of Fig. 15, the first tube is normally conducting and the triggers of V_2 and V_{T1} are biased. Application of a 'forward' pulse results in the ignition of V_2 and extinction of V_1. Each 'forward' pulse 'shifts the conduction' by one position to the right. After N 'forward' pulses an output pulse is produced at the rear terminal stage and the counter is reset to zero (V_1 is re-ignited). If the 'reverse' line is pulsed, the 'position of conduction' is shifted towards the left; when V_N is ignited by a 'reverse' pulse, an output pulse is produced at the front terminal stage. With the values indicated in Fig. 15 and $N=10$, the circuit can operate at frequencies up to 100c/s. However, if faster terminal stages are used the counter will work up to 400c/s.

The bi-directional counter can be used as an adding and subtracting device. For this purpose the pulses to be added are applied to the 'forward' line, and the pulses to be subtracted are fed into the 'reverse' line. It is essential that the two lines are not pulsed simultaneously. The minimum spacing between the 'forward' and 'reverse' pulses is about 3msec.

The decade counting circuit shown in Fig. 16 is almost identical with the staircase-waveform generator described in an earlier article[15]. The circuit consists of a counting chain (V_1 . . V_9) and a control univibrator (V_{10}, V_{11} and V_{12}). When the driving pulses are applied to the common input, V_1, V_2..V_9 are ignited successively. After the tenth pulse, V_{12} (being biased from the cathode of V_9) becomes ignited and its anode voltage drops to about 68V. Con-

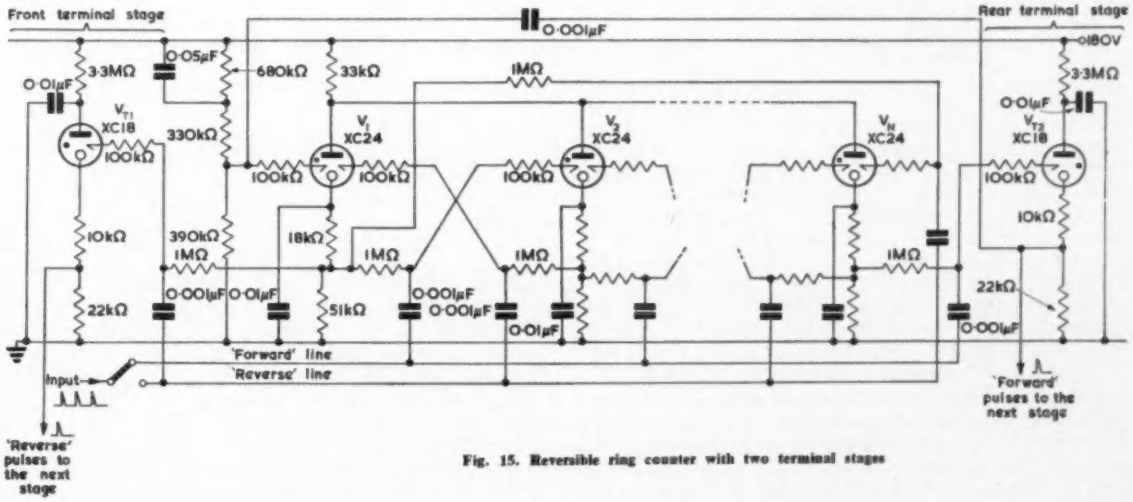


Fig. 15. Reversible ring counter with two terminal stages

sequently, V_{11} and all the tubes in the counting chain become extinguished. However, V_{11} is re-ignited after a few milliseconds by the pulse from the cathode of V_{10} and V_{12} is therefore extinguished. The anode voltage of V_{12} then rises to $V_b = 180V$ and the tubes in the chain are prepared for further operation. The circuit of Fig. 15 can operate at speeds up to at least 100c/s. It is not a particularly convenient counter circuit in that, in comparison with the counter of Fig. 14, it requires more of the order of several microseconds. The circuit will not normally be used as a counter, but it can be invaluable as a scanning device which will successively actuate a number of independent circuits.

Some of the disadvantages of the counter of Fig. 16 are overcome in the circuit of Fig. 17. The device consists of two chains of cold-cathode tubes: V_{A1}, V_{A2}..V_{AN} and V_{B1}, V_{B2}..V_{BN}. Initially only V_{B1} is conducting and V_{A1} is biased. A pulse applied to the input actuates V_{A1}

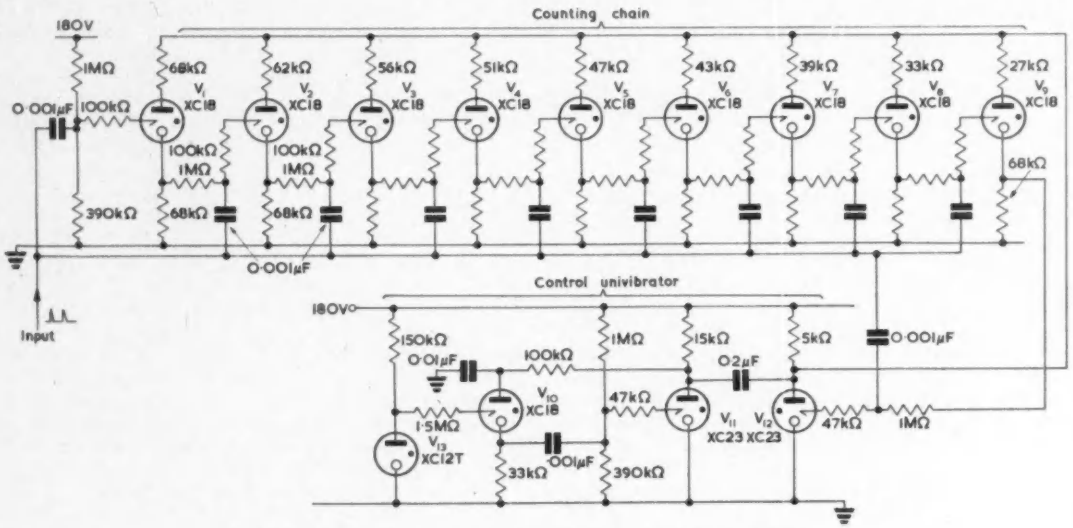


Fig. 16. Chain counter with N pulse outputs, controlled by a univibrator

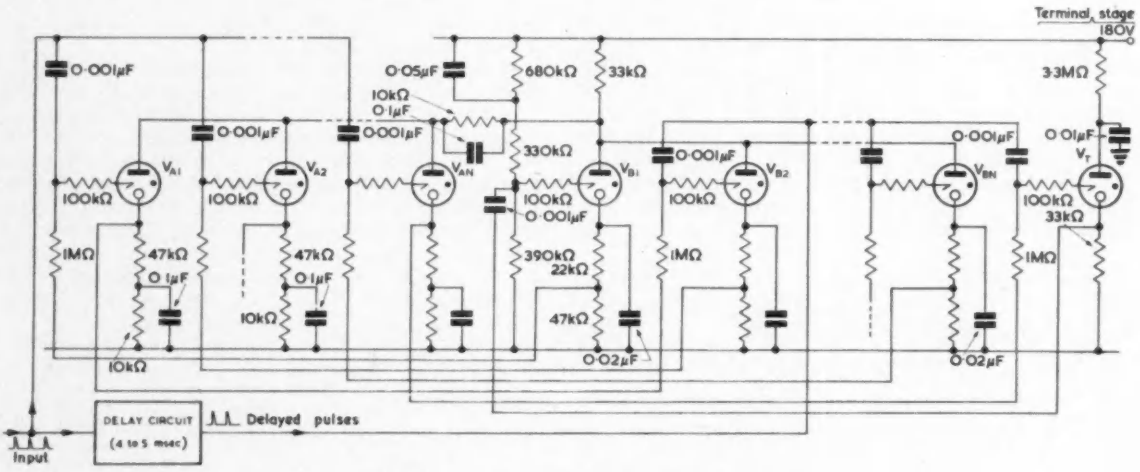


Fig. 17. Double-ring counter with N pulse outputs

tubes and higher current. Further, since the anode resistors of the counting chain have to be graded, it is not easy to vary the number of tubes in the chain. Also, it is not advisable to use more than 10 tubes in the chain, since the load on the univibrator will become too high.

The great advantage of the circuit of Fig. 16 is that it provides nine time-spaced pulses from nine sources (cathodes). The anode resistors are so chosen that the amplitudes of the pulses at the cathodes are almost identical and equal to about 50V. The pulses have a rise-time and results in the extinction of V_{B1}. A sharp edge having an amplitude of about 50V is therefore produced at the cathode of V_{A1} and the trigger of V_{B2} receives a biasing voltage. A delayed pulse is then produced and this ignites V_{B2} and results in the extinction of V_{A1}. The next input pulse produces an output pulse at the cathode of V_{A2} and 'shifts the conduction' to V_{B3}. At the appearance of the N^{th} pulse, V_{AN} is first fired and a pulse is then produced at the output of the terminal stage. This pulse re-ignites V_{B1} and the circuit is returned to its zero posi-

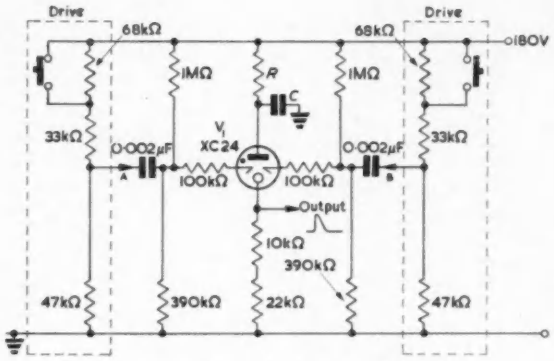


Fig. 18. Single-tube 'A or B' logic circuit

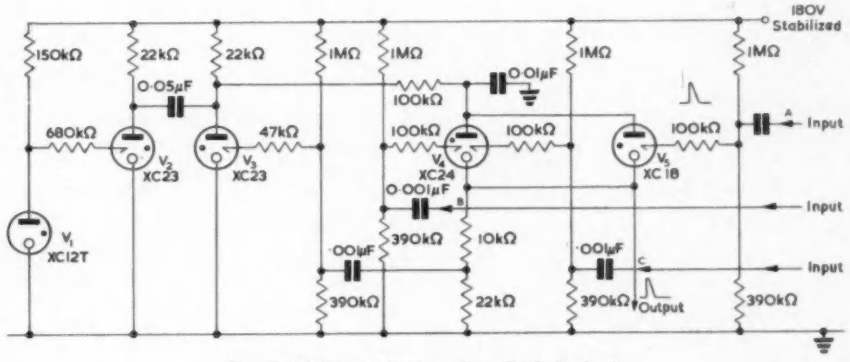


Fig. 19. Medium-speed 'A or B or C' logic circuit

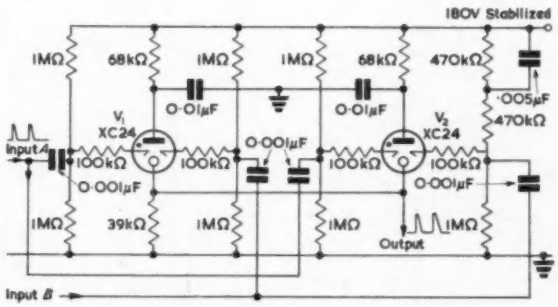


Fig. 20. High-speed 'A or B' logic circuit

tion. It is seen that the counter of Fig. 17, like the circuit of Fig. 16, generates N pulses at N sources. It can therefore be used as a scanning device. The circuit employs a comparatively large number of tubes and a delay univibrator, but has the advantage of great flexibility in that the number of output sources can easily be varied without changing the components and redesigning the circuit.

Logic Circuits

The counters in a system are concerned with evaluating the quantity of information fed into them from an external source. The function of dosing the information (that is sensing a particular quantity), directing it to suitable sources (gating), producing suitable output signals upon receiving the specified input signals and generating the resetting signals for the system is performed by the so-called logic circuits. Two principal classes of such circuits are known[7,17]: AND circuits or gates and OR circuits. The function of the AND circuits is to 'combine' a number of input signals (pulses) into a single output signal. It should perhaps be mentioned that the output signal is generated only if all the specified input signals are present. The purpose of the OR circuits is to combine N signals (pulses) from not more than N sources in such a way as to obtain N pulses from one output source. Several types of cold-cathode AND and OR logic circuits are known[7,17,19]. From the point of view of the 'consistency' of cold-cathode circuits these elements may be regarded as not entirely satisfactory, since they require substantial quantities of metal rectifiers[7,17,19] and some of them have to be operated by special pulses[7].

The circuits indicated below employ no rectifiers and are self-resetting, that is they return to the zero position after completing their operating cycle. Another feature of the circuits is that the input signals should be suitably spaced in time; it is not permissible that two signals should come simultaneously.

A simple A or B logic circuit is shown in Fig. 18. It is based on a single double-trigger triode. The anode resistor R is comparatively large (not less than 3·3MΩ) so that the tube is operating under self-quenching conditions. For each external pulse applied to either trigger, a pulse having an amplitude of about 100V is produced across the cathode resistor. Since the minimum practical value of C is 0·01μF, the operating speed of the circuit is limited to about 15c/s. The input pulses have to be spaced therefore by no less than 70msec. By combining a number of double-trigger tubes and one single-trigger tube in parallel it is possible to extend the circuit so as to accommodate any desired number of inputs. It is always possible to employ two single-trigger tubes instead of a double-trigger tube. The triggers of the circuit can easily be controlled by external bias sources. For this purpose the 1·0MΩ resistors are removed and the lower terminals of the 390kΩ resistors are applied to the bias points.

A three-input logic OR circuit capable of operating at frequencies up to 100c/s is shown in Fig. 19. The circuit consists of a control univibrator (V_1, V_2 and V_3) and two pulsing tubes (V_4 and V_5) whose anodes and cathodes are connected to common points. The trigger of V_3 is permanently ignited by the voltage from the anode of V_1, so that V_2 is normally conducting. The potential at the anode of V_3 is $V_b = 180$V, so that the anode capacitor of the pulsing tubes is charged to V_b. When a pulse is applied to either of the three inputs, one of the pulsing tubes is fired and a pulse is produced across the common cathode resistor (10kΩ + 22kΩ). The pulse ignites V_3, which results in a temporary extinction of V_2. However, before its anode potential can reach $V_b = 180$V, V_2 restrikes and extinguishes V_3. The anode potential of V_3 then rises to V_b and the pulsing capacitor is recharged. The amplitude of the output pulse is about 100V. The circuit can easily be extended by connecting more pulse tubes in parallel. The triggers of the pulsing tubes can be controlled by external bias sources.

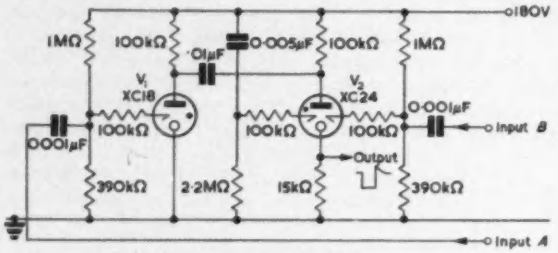


Fig. 21 Low-output 'A and B' logic circuit

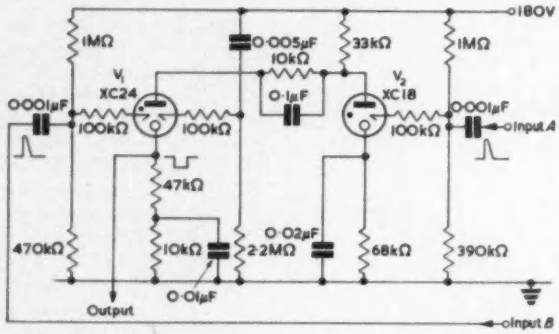


Fig. 22. 'A and B' logic circuit based on a pulse-binary circuit

Another type of logic OR circuit is shown in Fig. 20. This is similar to the circuit of Fig. 5 except that two double-trigger tubes are employed in order to provide two independent inputs. Initially V_2 is conducting and, an external pulse applied to either of the inputs, ignites V_1 and results in the extinction of V_2. An output pulse having an amplitude of about 65V is therefore produced across the common cathode resistor (39kΩ). The next pulse will re-ignite V_2 and extinguish V_1. The circuit can operate at frequencies up to 500c/s, so that the spacing between the pulses should not be less than 2msec. The circuit can easily be extended to accommodate any desired number of inputs. If three inputs are required, a binary of the type shown in Fig. 5 is added, the cathodes of all the tubes being connected to the common resistance (39kΩ). For four inputs it is necessary to combine in parallel two circuits of the type shown in Fig. 20; only one tube will be conducting at a time and the tube will be extinguished by igniting any other tube. The circuit of Fig. 20 cannot easily be controlled by an external bias, since its triggers require a voltage of 90V. This cannot usually be obtained from the standard cold-cathode tube circuits.

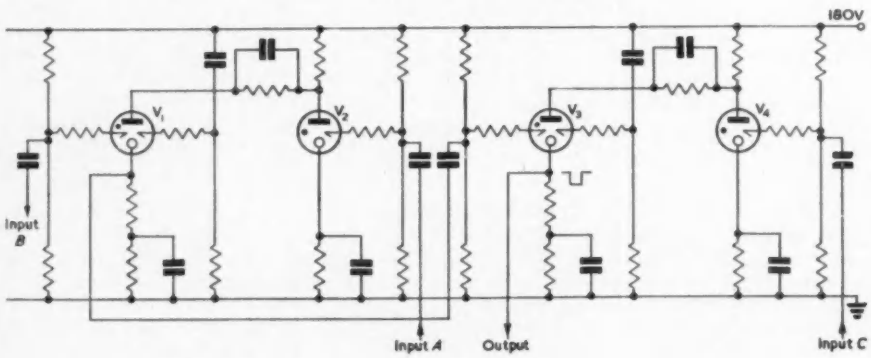
A modified anode-coupled binary of the type shown in Fig. 11 can be used as an *A* AND *B* logic circuit. The resulting device is shown in Fig. 21. It consists of a cold-cathode triode and a double-trigger tube, type XC24. The 0·005μF capacitor in the left-hand trigger of V_2 produces a strike pulse when the circuit is switched on. V_2 is thus normally conducting. When a pulse is applied to the *A* input of the circuit, V_1 becomes conducting and V_2 is extinguished. A pulse is then applied to the *B* input and V_2 is re-ignited, while V_1 is extinguished. As a result of this operation a sharp positive edge having a peak amplitude of about 30V is generated at the cathode of V_2. It should be clear that, for satisfactory operation of the circuit, the two input pulses cannot be applied simultaneously. Pulse *A* should come before pulse *B*, the spacing between them being not less than 3msec. Further, the circuit is blocked for *B* pulses until an *A* pulse is applied. The logic gate of Fig. 21 is not entirely satisfactory in that its output is too low to operate the standard cold-cathode circuits which require pulses of 50V.

A more satisfactory circuit is shown in Fig. 22. This is based on the binary of Fig. 13. When the supply voltage is switched on, V_1 is ignited by the 0·005μF capacitor. A pulse applied to the *A* input ignites V_2 and extinguishes V_1. By applying a pulse to the *B* input, the circuit is returned to its original state. A sharp positive edge having an amplitude of about 50V is therefore generated at the cathode of V_1. It should be clear that the *B* input is blocked until an *A* pulse is applied and the two pulses cannot be applied simultaneously. The spacing between the pulses should not be less than 5msec. The circuit can be controlled by external bias voltages. For this purpose, the 1·0MΩ resistors at the triggers are removed and the lower terminals of the 390kΩ and the 470kΩ resistors are connected to suitable bias sources. The operation of the circuit with biases is as follows: First, a biasing voltage is applied to the trigger of V_2; this is followed by an *A* pulse which will ignite V_2 and extinguish V_1. A bias voltage is then applied to V_1 and this is followed by a *B* pulse. When V_2 is re-ignited the biasing voltages are removed. The circuit thus becomes in effect a four-input AND gate. The time interval between the application of a bias and a pulse to the same trigger should not be less than 2msec.

In the circuit of Fig. 22 it is possible to employ two cold-cathode triodes, type XC18, instead of the double-trigger tube. Such an arrangement will have the advantage of eliminating the ionic coupling between the triggers.

If it is necessary to accommodate more than two pulse inputs (and biases), a number of circuits of the type shown in Fig. 22 are used. A three-input (*A* AND *B* AND *C*) circuit is shown in Fig. 23. It is seen that this consists of two pulsing binaries with V_1 and V_3 being normally on. The operating sequence for the circuit is as follows.

Fig. 23. 'A and B and C' logic circuit based on two pulse-output binaries



Pulses *A* and *C* can be applied simultaneously or *C* should come before *A*. Pulse *B* comes later and resets the first binary (V_1 and V_2). Its output pulse then resets the second binary (V_3 and V_4) and an output pulse is therefore produced at the cathode of V_3. Again the circuit of Fig. 23 can be controlled by external bias voltages. An AND circuit for four pulse inputs can easily be devised by adding another binary to the circuit of Fig. 23. More inputs will be accommodated by adding further binaries.

Shift Matrix (Register) Element

The function of controlling the sequence of operations in an automation system can be performed by a shift matrix or register. In effect, an element of this type performs the programming of the system. Several different shift registers are known[2,7,15]. In general these are fairly complicated circuits requiring special drive waveforms.

A comparatively simple shift register, requiring a relatively large number of tubes, is shown in Fig. 24. The circuit consists of two rows of five tubes. A half of the tubes are double triodes, type XC24, and these become conducting when the supply voltage is switched on, since they receive a pulse to one of their triggers through the 0·002μF capacitors. A pattern of conducting tubes is thus established: V_1 and V_3 in the upper row and V_7, V_9 and V_{10} in the lower row. Each tube of the upper row is anode-coupled with the corresponding tube of the lower row. On the other hand, the tubes in each row provide bias voltages for each other; thus in the upper row, V_1 biases V_5 and V_3 provides the bias for V_2. The pulsed triggers of all the tubes are connected to a common pulse source. When a pulse is applied to the common input, the tubes which are biased become conducting. Thus in the upper row V_2 and V_5 are ignited; in the lower row V_6 and V_8 are made conducting. As a result of this, V_1, V_7, V_9 and V_{10} are extinguished. It is seen therefore that the pattern of conducting tubes in each row has been shifted forward one step. Each additional pulse results in a further one-step shift until after five pulses the circuit returns to its initial position.

The circuit of Fig. 24 shows a fixed pattern. It should be realized, however, that by providing each pulsed trigger with a push-button switch which is normally off, the pattern can be made adjustable. The method of igniting a particular tube is illustrated in Fig. 25. The tube is struck by momentarily depressing the switch. By adopting this method it is possible to eliminate all the double-trigger tubes, but the pattern will not automatically be established when the supply voltage is switched on It should also be borne in mind that in Fig. 24 only five tubes should be made conducting at a time.

The register of Fig. 24 can easily be extended both vertically and horizontally. The number of tubes in a row can be *N* and it is possible to have *M* rows (in general $M < N$). The anodes of all the corresponding tubes from each row should be connected to a common resistance (33kΩ). A desired pattern will be established by igniting *N* tubes in suitable positions. In general each row will comprise at least one conducting tube, but it is possible to have some rows without any conducting tubes. The extension of the circuit of Fig. 24 results in a true shift matrix. The output signals of this device are in the form of bias voltages and can be taken from the tapping point (between 22kΩ and 47kΩ) of the cathode resistance of any tube.

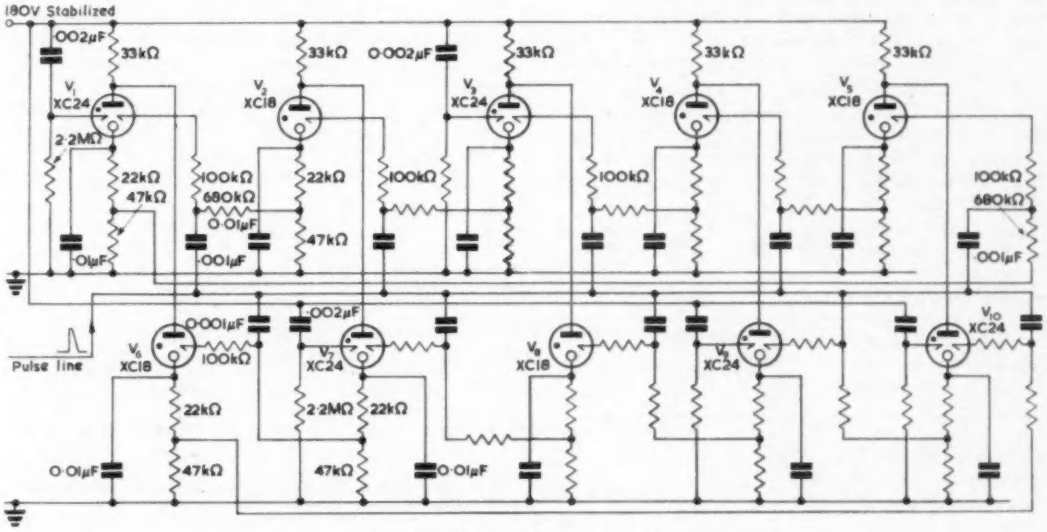


Fig. 24. Shift matrix (register) element

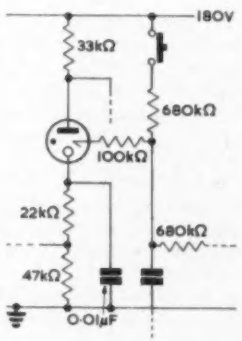


Fig. 25. Method of igniting a tube in a shift matrix

(To be continued)

A Linear to Logarithmic Convertor Unit for use with a Linear Counting Ratemeter

By J. Turnbull* and D. N. Walder*, M.D., F.R.C.S.

A description is given of a convertor unit which, fed from a scale of two stage capable of generating negative going square waves (30V amplitude), will give an approximately logarithmic output over two decades. By switching it is possible to select full scale deflexion of the output meter over a counting range of either 10 to 1 000 or 100 to 1 000 pulses per second. Recorder outputs are available for 5mA or 100mV.

(Voir page 265 pour le résumé en français: Zusammenfassung in deutscher Sprache auf Seite 272)

IT has been established that, with certain provisos, the rate at which an injected depot of isotonic radioactive sodium chloride is cleared from skeletal muscle is linearly related to the blood flow through the muscle[1]. Observation of the rate of clearance of injected radioactive sodium therefore provides a convenient method of measuring muscle blood flow in animals and man. A clinical test to determine the vascular sufficiency of muscle in patients suffering from peripheral vascular disease has been developed[2]. At any given flow, the clearance of the radioactive sodium occurs exponentially so that direct recording of the changes in radioactivity of the depot with time, as obtained by the use of a linear ratemeter and recorder, do not provide an easily interpreted record of blood flow changes. It is more convenient if the logarithm of the radioactivity can be recorded. A logarithmic ratemeter is available commercially, but it is not suitable for the present investigations because it is a general purpose instrument and covers four decades either from 1 to 10 000 or 10 to 100 000p/sec. In this present work it is essential that the *total activity* of the radioactive sodium depot injected into the muscle is kept as small as possible to avoid unnecessary radiation hazard to the subject and also that the *volume* of the injection should be kept small in order tc avoid spread to adjacent tissues. Under present working conditions using a Geiger Müller tube type GM4, the maximum number of pulses per second available at the start of the recordings is approximately 1 000. A linear type ratemeter was already in use for this work so that it was decided to construct a linear to logarithmic convertor unit to be used in conjunction with this equipment. Fig. 1 shows schematically the arrangement of the apparatus.

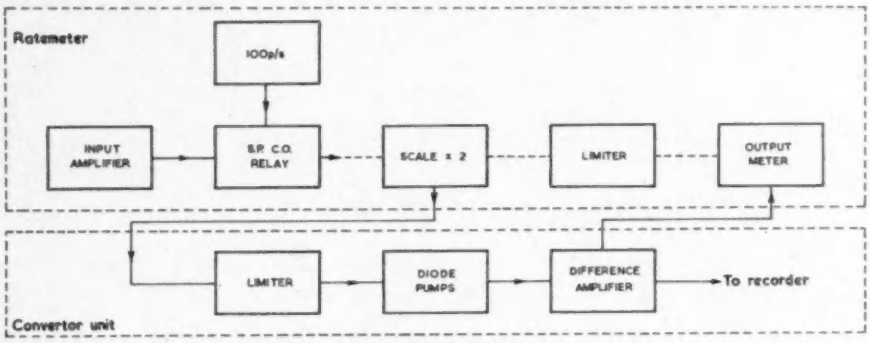


Fig. 1. The ratemeter and convertor unit

Principle

The basis of the linear to logarithmic convertor unit consists of a series of diode pumps as described by Cooke-Yarborough and Pulsford[3].

Circuit Description (Fig. 2)

By alternately switching the grids of the limiter valve V_1 with negative going square waves such as generated by a scale of two stage each half of the valve conducts in turn. The amplitude of current flow is controlled by the total cathode resistance of R_2 and RV_1. The output taken from the anode loads is a square wave, the amplitude of which depends on the settings of RV_1, RV_2, RV_3 and RV_4. These output voltages are applied to the diode pump feed capacitors which charge up through the diodes *a* and their leak resistors, and discharge through diodes *b*. Time-constants of the tank circuits are provided, these being selected by switch S_2. The sum of the currents flowing through R_6, R_7, R_8 and R_9 develop a voltage across R_{10} and R_{11} which is approximately proportional to the logarithm of the input pulses to V_1. Range changing is carried out in the grids and cathodes of the difference amplifier formed by V_6 and V_7, the appropriate decades being selected by switch S_3. As the output meter in the cathodes of the difference amplifier should register zero deflexion for a finite number of pulses, a reverse current will flow through the meter if the input pulse rate falls below 10p/sec on range one and 100p/sec on range two. To prevent this switch S_1 is so arranged that in the standby position it operates a relay in the ratemeter, Fig 1, which feeds a source of 100p/sec from the unsmoothed side of the high tension filter through the ratemeter to the convertor unit. The resultant output gives half-scale deflexion on range one and zero deflexion on range two. In addition to preventing the reverse flow of current, the source of 100p/sec also provides decade check points. Alternatively switch S_1 can be so arranged that in the standby position it feeds into the grid of valve V_6 either 8V positive on range one or 16V positive on range two.

Setting Up the Difference Amplifier

RV_6 is adjusted to the same value of resistance as the 5mA recorder movement used with the instrument. With the decade range switch S_3 in the 10 to 1 000 position, the

* University of Durham.

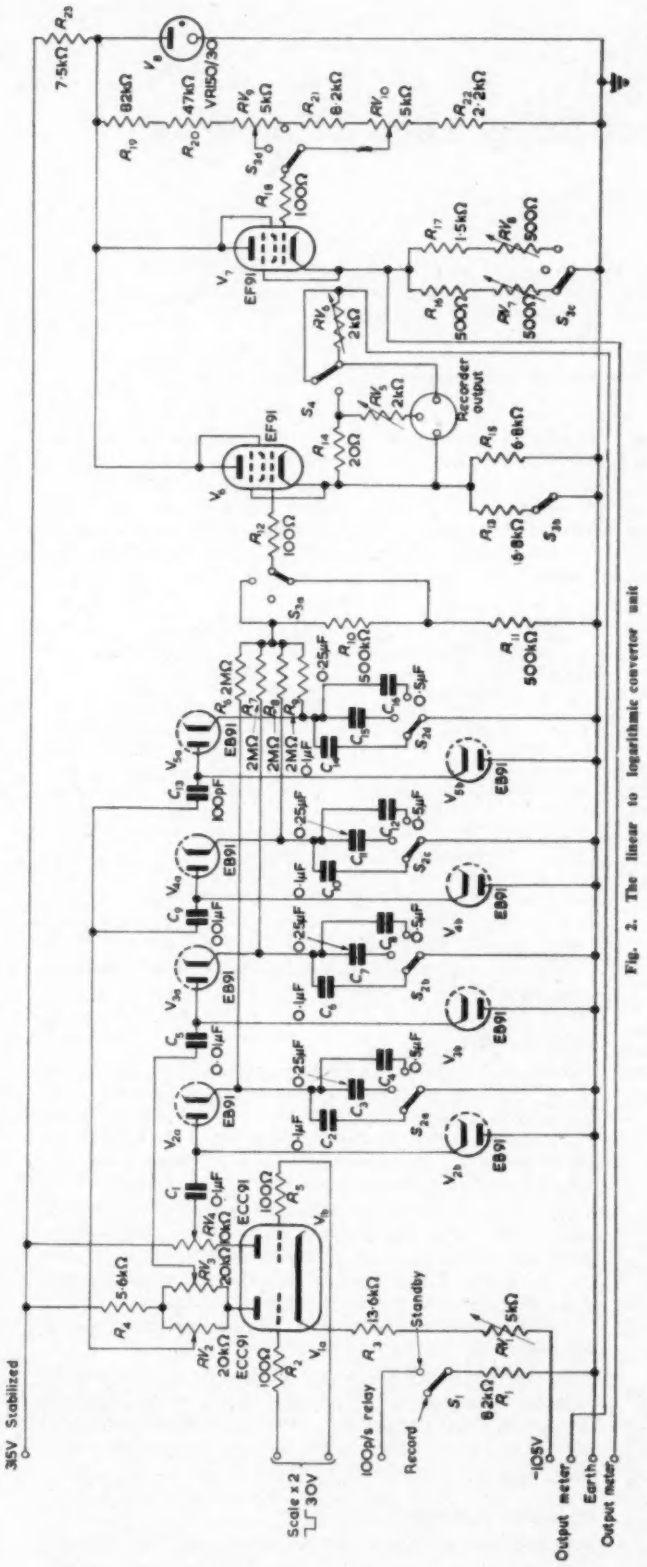


Fig. 2. The linear to logarithmic convertor unit

output recorder switch S_4 in the 100mV position and the junction of R_6, R_7, R_8 and R_9 disconnected from R_{10} known positive voltages are applied across R_{10} and earth. With 8V applied RV_{10} is adjusted so that the output meter reads zero, with 24V applied RV_7 is adjusted for full-scale deflexion. With the range decade switch S_3 in the 100 to 1 000 position, 16V is applied and RV_9 adjusted to give zero reading of the output meter and with 24V applied RV_8 is adjusted for full-scale deflexion. These sequences have to be repeated several times until the scale readings are correct for the applied voltages.

Setting Up the Diode Pump Circuits

In plotting the response of these circuits, a 0 to 120μA mirror scale meter is connected to the convertor output socket, connexion being made to the pins which go to V_6 cathode and RV_5. With switch S_4 in the 100mV position and a full-scale deflexion on the output meter, the value of RV_5 is reduced until a reading of 100μA is obtained. This outlet from the socket which is not used under operating conditions is retained for periodic calibration checks. With switch S_2 set for the 10 to 1 000p/sec range, square wave pulses are fed into the ratemeter and the following adjustments made: RV_4 is adjusted to give zero reading for 10p/sec; RV_3 is adjusted to give a reading

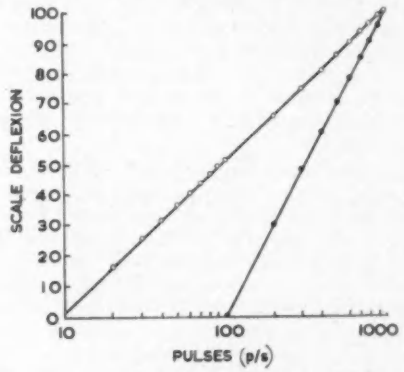


Fig. 3. Response curves of convertor unit for an input of 10 to 1 000p/s and 100 to 1 000p/s

of 50μA for 100p/sec and RV_2 is adjusted to give a reading of 100μA for 1 000p/sec. This sequence is repeated until the appropriate readings correspond to the pulse rate input. A series of response curves is then plotted, adjustments being made to RV_2, RV_3 and RV_4 after each plot until the response shown in Fig. 3 is obtained. The voltages shown in Fig. 2 at the diode pump capacitor feeds are measured on an oscilloscope at an input of 1 000p/sec after completion of the instrument.

Power Supplies

The filament supply for the valves in the convertor unit is obtained from a separate constant voltage transformer not shown in Fig. 2, but housed in the convertor unit. The stabilized 315V at 30mA and negative 105V at 6 mA are obtained from the ratemeter.

Acknowledgment

The ratemeter referred to in this article is an EKCO ratemeter type N522.

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Precise Frequency Control for a Rotary Convertor

By M. J. Tucker*, B.Sc., F.Inst.P.

The Royal Research Ship 'Discovery II' has been provided with a 50c/s power supply whose frequency is precise to approximately 1 part in 10^5, by locking the phase of a small rotary convertor to that of a 50c/s reference signal derived from a quartz-crystal oscillator.

(Voir page 265 pour le résumé en français; Zusammenfassung in deutscher Sprache auf Seite 272)

MANY devices common in shore laboratories use the 50c/s mains supply as a precise frequency: synchronous-motor chart drives, timing and programming switches, and synchronous clocks, for example. It is also useful for such purposes as checking audio-frequency oscillator scales and cathode-ray oscillograph time-base calibrations. Oceanographic research is depending more and more on electronic equipment, and it would be a considerable convenience to have a precision 50c/s supply available on research ships. One possibility used in the past has been to connect a power amplifier to the output of a suitable oscillator, but the amount of power conveniently obtainable in this way is limited.

The most satisfactory solution would be to control the frequency of the main a.c. generator, since this would avoid the necessity for separate wiring for the precision supply. It is hoped to do this in the new research ship being designed for the National Institute of Oceanography, but as an interim measure and to gain experience with this type of system, it was decided to control the frequency of a 250W rotary convertor for use in the Royal Research Ship 'Discovery II'.

One of the important uses of such a supply is to allow accurate and synchronous timing in several different places on the ship during survey work. For this purpose, an accuracy of at least 1 part in 10^4 is desirable, and in fact, an accuracy of approximately 1 part in 10^5 has been achieved by locking the phase of the output of the convertor to that of a reference signal obtained by dividing down the frequency of a quartz-crystal oscillator.

Details of the System

A block diagram of the system is shown in Fig. 1. A phase-comparator gives a d.c. voltage proportional to the phase difference between the output of the rotary convertor and that of the reference signal. This is amplified and used to control the rate of rotation of the convertor by means of an auxiliary field winding. If the phase of the convertor tends to advance, the field is increased; if the phase tends to lag, the field is decreased.

The control and power-supply circuits are shown in Fig. 2. The reference signal is a square wave with a peak-to-peak amplitude of 12V. This is phase-split and fed to a balanced phase-sensitive rectifier. The output of the rectifier contains the required d.c. signal, together with 100c/s ripple which is smoothed in *RC* circuits. A cathode-follower buffer stage feeds a phase-advance circuit, followed by a voltage amplifier feeding the control valve. The auxiliary field and control valve are fed directly from the 110V d.c. ship's main supply. Negative feedback from the control current to the voltage amplifier via a phase-lag network has the effect of introducing phase-advance in the main path, and increases the output impedance (see below)

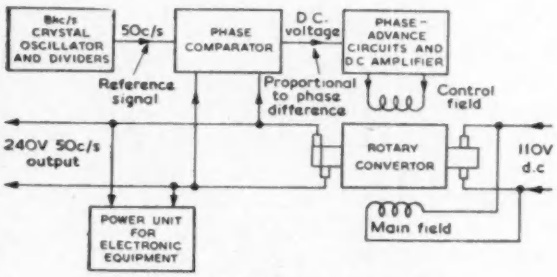


Fig. 1. General arrangement of the equipment

The control field when fully energized takes 175mA with a 50V drop across it, and increases the total field by approximately 20 per cent.

Loop Stability

Frequency may be defined as the rate of change of phase. Thus, the process of measuring phase and using the error to control the frequency of the convertor represents an integration in the feedback loop, and introduces a $\pi/2$ phase lag and a voltage response inversely proportional to the frequency of the error signal. There are two other inherent sources of phase lag: the inductance of the field winding and the inertia of the rotor. Unfortunately, these are liable to have similar time-constants, and can give a combined phase-lag of $\pi/2$ without much attenuation. There is thus a considerable advantage in reducing the time-constant of the field by making the dynamic impedance of the control circuit high.

In the present case it was not possible to measure the relevant characteristics of the convertor before designing the control circuit, which was therefore based on intelligent guesswork. The original circuit required some minor modifications to make the system stable.

Operating Experience

It was found that the convertor could be switched straight into the 110V d.c. supply. The convertor initially

* *National Institute of Oceanography.*

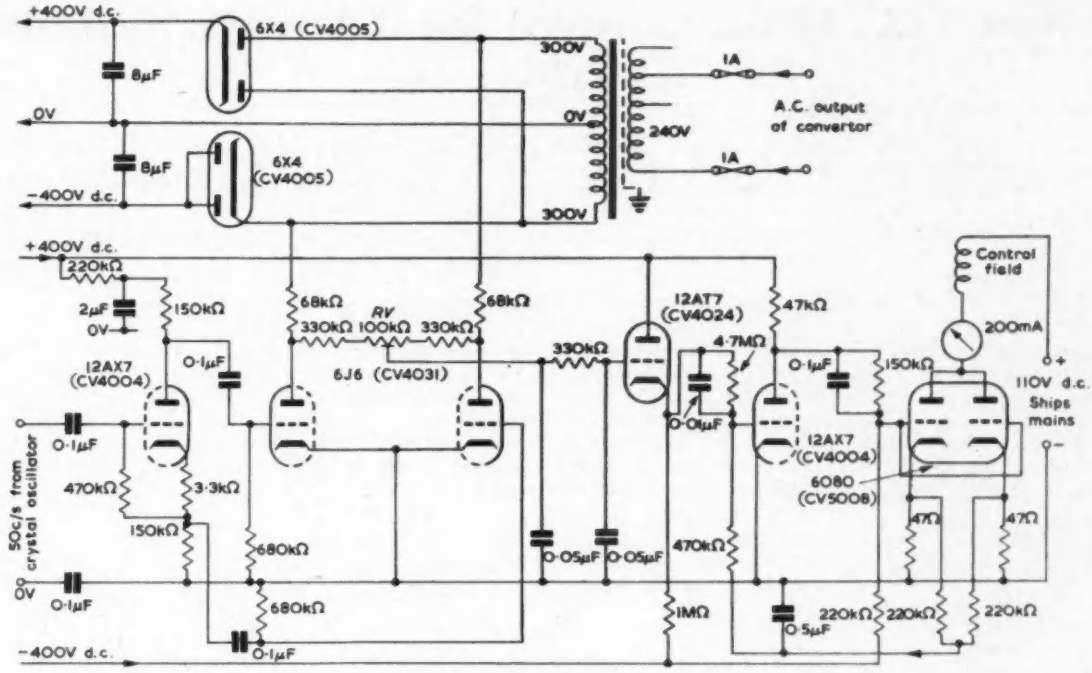


Fig. 2. The control and power supply circuits

runs faster than 50c/s, but as the electronic circuit warms up, it slows down and locks automatically. If the power supply fails momentarily (for example, when the ship's generators are changed) the convertor again locks automatically. It was found, however, that if another load was switched into the same 110V d.c. circuit and the voltage momentarily dropped just below the control range, a sustained instability could be produced. This could be stopped by switching off the convertor input for approximately one second, but to avoid this trouble the convertor was connected into a supply circuit with better regulation.

The crystal oscillator (an almost-standard crystal chronometer bought from a commercial firm) gave considerable trouble, and on one occasion started giving approximately 55c/s. The convertor was unable to lock to this, so that the field current fluctuated and large low-frequency alternating currents were generated in the armature. This resulted in overheating.

After the 'teething troubles' had been overcome, the system worked well, and at the time of writing has been in satisfactory operation for some months.

A Higher-Power Convertor or Motor-Alternator

It is thought that it would be preferable to control the field in the manner shown in Fig. 3. Here, the control is performed by a series transistor (or bank of transistors if necessary). The currents and voltages are suitable for power transistors now available. The shunt resistor R_1 is arranged to drop 20 per cent of the supply voltage when the transistor is cut off, thus preventing surge voltages destroying the transistor, protecting the convertor in case of a failure in the control circuit, and reducing the power dissipated by the transistor.

Negative feedback from R_2 increases the dynamic impedance of the control circuit, thus reducing the time-constant of the field. This makes it easier to achieve loop-stability in the control system.

This arrangement also has the advantage of using a

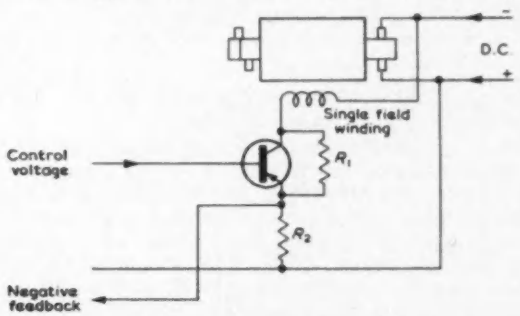


Fig. 3. Suggested method of control for a higher powered convertor

standard field arrangement, so that if the control circuits fail, a standard manual control can be switched in to maintain a 50c/s supply (though not, of course, with a precise frequency).

With a large machine, starters will be required, and it will be necessary to arrange for the phase-control circuit to be switched in when the phase-relationship is correct. Were this not done, large current surges would be produced until the machine locked.

Similarly, automatic protection devices would be required so that in the event of a failure in the clock or control circuit, large surge currents would not be drawn from the d.c. supply.

A New D.C. Level Control for Adaptive Systems

By R. A. Johnson* and J. D. Hill†

A novel electronic circuit is described and analysed which maintains the potential drop across a load constant to within a fraction of one per cent while permitting the d.c. level of the load to be varied through a wide range. The circuit requires only standard tolerance electronic components and affects the high precision by an error compensation technique.

An example design is presented allowing a 20kΩ load to be shifted through 200V while maintaining the 200V across it constant to within ±0·2 per cent.

(Voir page 265 pour le résumé en français; Zusammenfassung in deutscher Sprache auf Seite 272)

A COMMON element used in analogue computers and feedback control systems to transform a shaft position into a voltage is the (usually) d.c. excited, linear potentiometer, the position of the wiper on which indicates the shaft position. The transfer function of such an element is a constant gain given usually in volts per radian by the ratio of supply voltage to the total radian excursion of the potentiometer. This signal gain then depends directly on the potential difference across the unit.

It is sometimes necessary or advantageous in certain types of adaptive control systems to adjust the d.c. level of the potentiometer without disturbing the gain constant, that is, without altering the voltage applied across it. This note describes the design of such a system. As an example, a particular design is carried out in detail which allows the level of a 20kΩ potentiometer to be adjusted through 200V without changing the 200V across it by more than ±0·4V or ±0·2 per cent and without the use of special or premium components. Due to the excursion voltages, required accuracy and power levels involved (2W in the controlled element) this example probably represents one of the most stringent designs in its class and thereby proves the generality of its application.

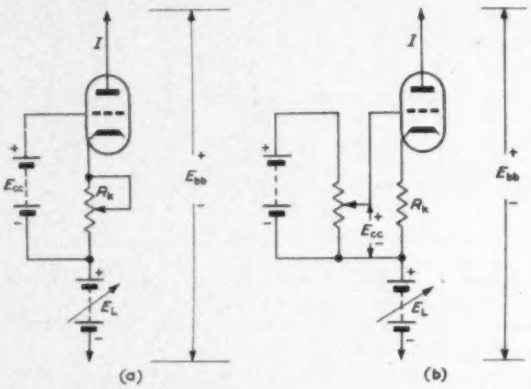


Fig. 1. (a) A simple almost constant current circuit
(b) Its equivalent without the high wattage variable cathode resistor

Preliminary Considerations

The system to be described in the next section was based on a circuit[1] shown in Fig. 1(a) in which the value of the cathode resistor, R_k, is adjusted to deliver the required current, I_{b1}, at the voltage level E_{L1}. A high positive fixed bias E_{cc} produces an almost level bias line so that when the load voltage is changed to E_{L2} the change in current to I_{b2} is small. Using a 6SN7 triode and a 400V supply, a voltage level change from 0 to 50V could be attained with resulting current change less than 2 per cent at a 5mA level[2]. The circuit of Fig. 1(b) accomplishes the same results without the use of a relatively high powered variable resistor.

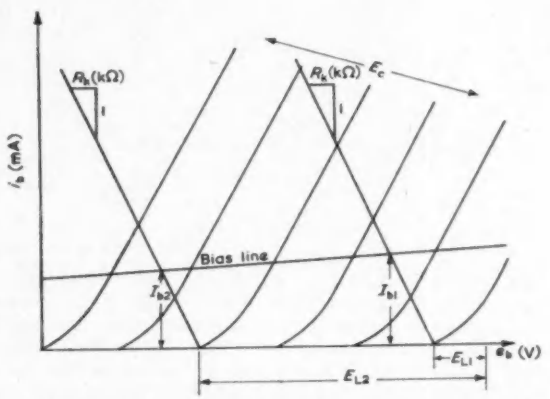


Fig. 2. Characteristics, load and bias lines of the circuit of Fig. 1(a)

Since, ideally, the bias line should be level, that is one of constant current, and since the slope of the line depends on the value of the cathode resistor R_k, if this resistor could be altered with the level in such a way as to counteract the effect of the bias line even roughly, most of the 2 per cent change could be compensated and a system developed to permit much larger excursions in voltage level with greater current regulation as required.

System Design

A system found to satisfy the above requirement is shown in Fig. 3 in which R_L represents the potentiometer of varying level, V_1 the control valve similar to that in the preliminary design and V_2 the controllable part of the cathode resistor. The level of the chain is entirely controlled by the two grid potentials E_{cc1} and E_{cc2}. The negative return for the chain allows the midpoint level of the load (E_M) to be varied both positively and negatively.

The operation of this circuit is given by equations (1) to (8) below.

$$I = \frac{E_{bb}^{+} - E_{bb}^{-}}{R_{b1} + R_{b2} + R_L + R_{k1} + R_{k2}} \quad \ldots\ldots (1)$$

$$E_{c1} = E_{cc1} - E_{k1} \quad \ldots\ldots (2)$$

$$E_{c2} = E_{cc2} - E_{k2} \quad \ldots\ldots (3)$$

$$E_{k1} = E_{bb}^{+} - E_{b1} \quad \ldots\ldots (4)$$

* University of Manitoba, Canada.
† Defence Research Board, Canada.

$$E_{k2} = E_{bb}^{-} + IR_{k2} \quad \ldots\ldots (5)$$

$$E_{b1} = E_{bo1} - \mu_1 E_{c1} + r_{a1} I \quad \ldots\ldots (6)$$

$$E_{b2} = E_{bo2} - \mu_2 E_{c2} + r_{a2} I \quad \ldots\ldots (7)$$

$$E_M = E_{bb}^{+} - I(R_{b1} + R_{k1} + R_L/2) \quad \ldots\ldots (8)$$

where $R_{b1} \equiv E_{b1}/I$ and $R_{b2} \equiv E_{b2}/I$ are the beam resistances, r_{a1} and r_{a2} the incremental anode resistances, μ_1 and μ_2 the amplification factors and E_{bo1} and E_{bo2} the equivalent linear quiescent anode-to-cathode potentials of the valves V_1 and V_2 respectively. The grid potentials E_{cc1} and E_{cc2} may be assumed to result from a single driving voltage E_s, through gain constants $-k_1$ and k_2 respectively, so that:

$$E_{cc1} = -k_1 E_s \quad \ldots\ldots (9)$$

$$E_{cc2} = k_2 E_s \quad \ldots\ldots (10)$$

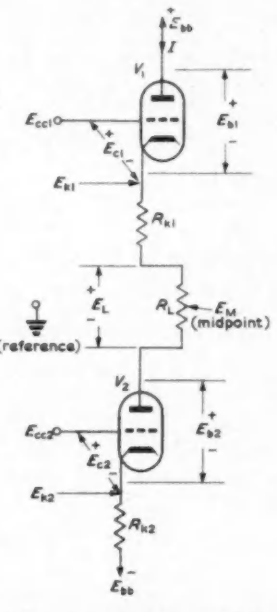


Fig. 3. The constant current chain
All potentials shown are with respect to the reference except where otherwise indicated

Equations (9) and (10) can most easily be implemented by a phase-splitting network as will be shown in the design example.

Total differentials of the left-hand sides of the above equations (assuming a linear system) are given in equations (11) to (20) where $r \equiv R_{b1} + R_{b2} + R_L + R_{k1} + R_{k2}$.

$$dI = -(I/r)(dR_{b1} + dR_{b2}) \quad \ldots\ldots (11)$$

$$dR_{b1} = (1/I)\,dE_{b1} - (R_{b1}/I)\,dI \quad \ldots\ldots (12)$$

$$dR_{b2} = (1/I)\,dE_{b2} - (R_{b2}/I)\,dI \quad \ldots\ldots (13)$$

$$dE_{b1} = -\mu_1\,dE_{c1} + r_{a1}dI \quad \ldots\ldots (14)$$

$$dE_{b2} = -\mu_2\,dE_{c2} + r_{a2}dI \quad \ldots\ldots (15)$$

$$dE_{c1} = dE_{b1} + dE_{cc1} \quad \ldots\ldots (16)$$

$$dE_{c2} = -R_{k2}\,dI + dE_{cc2} \quad \ldots\ldots (17)$$

$$dE_{cc1} = -k_1 dE_s \quad \ldots\ldots (18)$$

$$dE_{cc2} = k_2 E_s \quad \ldots\ldots (19)$$

$$dE_M = -I dR_{b1} - (R_{b1} + R_{k1} + R_L/2)\,dI \quad \ldots\ldots (20)$$

The defining equations for the beam resistances have been used to simplify equations (12) and (13).

These equations lead to the signal flow graph of Fig. 4(a) which simplifies easily to that of Fig. 4(b) from which the following two pertinent operating equations may be found:

$$(dI/dE_s) = (D/R) \quad \ldots\ldots (21)$$

and:

$$(dE_M/dE_s) = \frac{-k_1\mu_1}{1+\mu_1} - (D/R)\,[R_{k1} + (R_L/2) + r_{a1}/(1+\mu_1)] \quad \ldots\ldots (22)$$

in which:

$$D = k_2\mu_2 - k_1\mu_1/(1+\mu_1) \quad \ldots\ldots (23)$$

and:

$$R = R_L + (1+\mu_2)\,R_{k2} + R_{k1} + r_{a2} + r_{a1}/(1+\mu_1) \quad \ldots\ldots (24)$$

From equations (21) and (23) it is immediately evident that the current through and, hence, the voltage across the load R_L become invariant with input signal provided $D = 0$ or

$$(k_2/k_1) = (\mu_1/\mu_2)\frac{1}{1+\mu_1} \quad \ldots\ldots (25)$$

under which condition the incremental gain of the system from input dE_s to the level of the midpoint of the load, dE_M becomes:

$$(dE_M/dE_s) = \frac{-k_1\mu_1}{1+\mu_1} \quad \ldots\ldots (26)$$

If V_1 and V_2 are identical valves with high amplification factor, i.e. $\mu_1 = \mu_2 = \mu \gg 1$ then equations (25) and (26) further simplify to:

$$(k_2/k_1) = (1/\mu) \quad \ldots\ldots (25a)$$

and:

$$(dE_M/dE_s) = -k_1 \quad \ldots\ldots (26a)$$

The incremental gain of the system then becomes simply that of the driving unit between the input and the grid of V_1. This confirms the concept of the upper valve operating as a cathode-follower with a very large (ideally infinite) cathode resistor.

Design Example

A system is to be designed which allows the midpoint of a 20kΩ potentiometer to be varied between ±100V maintaining a constant current of 10mA through it. Available supplies are ±300V. To simplify the design, valves V_1 and V_2 are to be identical with $R_{k1} = R_{k2}$.

Since the potential of the top of the load must vary from 0 to +200V, the anode potential E_{b1} (and E_{b2}) must also change by 200V at a current level of 10mA. A triode which permits such a change without leaving the 'linear' region on its characteristics is one half of a 5687, the anode characteristics for which are shown in Fig. 5. To minimize power dissipation and at the same time avoid excessive grid currents the most suitable operating range for the valve lies between anode potentials of 50 and 250V. The latter value when applied to V_1 occurs when the load is at its lowest potential, i.e. when its upper end is at the

TABLE 1
Grid driving voltages for the extremes and the mean values of E_M

$E_M(V)$	$E_{c1}(V)$	$E_{cc1}(V)$	$E_{c2}(V)$	$E_{cc2}(V)$
+100	−1	+249	−13	−263
0	−7	+143	−7	−257
−100	−13	+37	−1	−251

reference level. A 50V drop must then be produced by R_{k1} which fixes its value at 5kΩ and since the circuit is balanced sets R_{k2} to 5kΩ also.

The required grid-to-cathode potentials of the two valves vary from −1 to −13V about a mean of −7V. By the use of equations (2) and (3) and the definition of E_M the

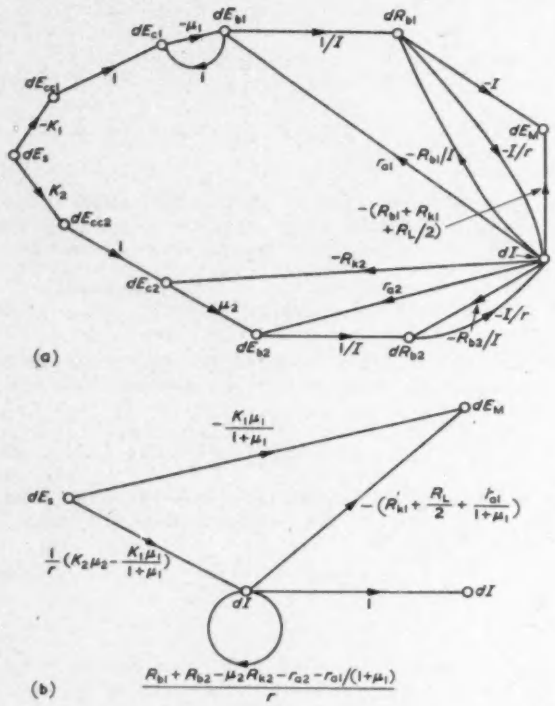


Fig. 4. (a) Initial flow diagram
(b) Simplified flow diagram

values of E_{cc1} and E_{cc2} shown in Table 1 are constructed from which:

$$(dE_{cc1}/dE_{cc2}) = (-k_1/k_2) = -(212/12) = -17{\cdot}67 \quad .. \quad (27)$$

This gain ratio can be realized by a standard phase-splitter circuit with proper choice of anode and cathode resistors. The d.c. levels required are set by means of the regulator tube and potentiometer combination shown in Fig. 6 which also illustrates the complete design.

Experimental measurements indicate that the potential across the load actually changes by ±0·4V or by ±0·2 per cent, over the 200V range. The driving voltage excursion was 6·2V. By calculation of R (equation (24)) using average values of r_{a1}, r_{a2}, μ_1 and μ_2 over the operating range and use of equation (21) the average D was found to be −0·20 which value yields a negligible second term on the right-hand side of equation (22). The average gain of the system, calculated as the ratio of the total excursions of E_M and E_s, yields a value of k_1 from equation (22) of −32·3. The theoretical value using average values of μ and r_a of the driver valve is −30. Considering the fact that the driver valve signal excursion must be high to produce the required level variation, the discrepancy of some 8 per cent between the two values is not unreasonable.

The high signal on the driver valve introduces a non-linearity into the system; the overall incremental gain varies from approximately 16 to 100. This effect has been reduced to less than 1 per cent non-linearity by using a unity feedback loop around the level setting device and its associated standard pre-amplifiers.

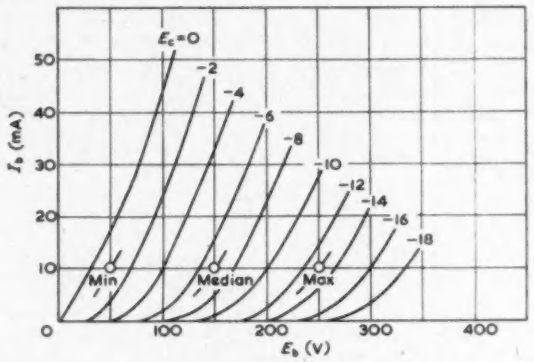


Fig. 5. Anode characteristics and operating ranges of one-half of a 5687 used in the example

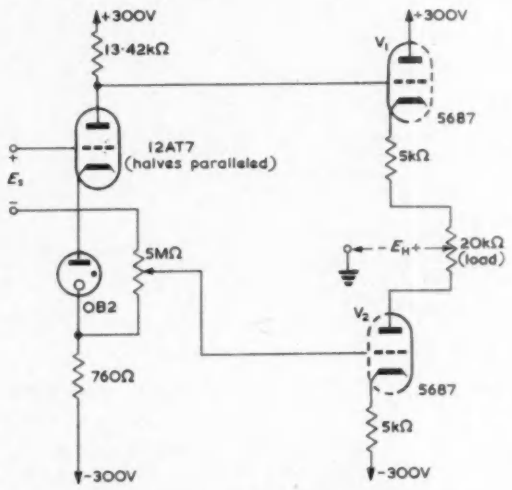


Fig. 6. Complete design considered in the example

Conclusion

The circuit described should prove to be a highly useful component in systems which are required to adapt two or more signals to a common level. The high accuracy attainable in the device without the use of precision components contributes much in its favour.

Due to the details of design included the method should be immediately useful for other systems requiring different voltages, power levels and signal excursions. It also provides an example of d.c. thermionic valve circuit analysis which is so often omitted in texts on the subject.

Acknowledgment

The authors wish to acknowledge aid received from the National Research Council of Canada (Research Grant A 584 and Bursary) for the project in connexion with which the above system was designed.

REFERENCES

1. The only reference found by the authors to this circuit was in a Stanford University, Department of Electrical Engineering Laboratory Experiment entitled: "The Pole-Zero Machine".
2. A complete analysis of this circuit is given in BRIDGES, E., A Network Function Simulator, M. Sc. Thesis, University of Manitoba, 1958.

BOOK REVIEWS

Video Tape Recording

By Julian Bernstein. 268 pp. 175 figs. Medium 8vo. Chapman and Hall Ltd. 1960. Price 72s.

MR. BERNSTEIN has set himself the task of describing the mechanism of video tape recording in a way that can be understood by both engineers and interested laymen. Within the limitations of this approach he has dealt with the subject thoroughly.

The book begins with an elementary introduction to the related subjects of television principles and recording processes. Study of these chapters will prepare the less technical reader for the rigours of the remainder of the book. In Chapter 6 the present methods of recording television on magnetic tape are introduced. This is followed by a survey of the circuits used in current video recorders, achieved with the aid of comprehensive block diagrams and detailed circuit descriptions. Colour correction techniques used in the United States to allow the widespread recording of N.T.S.C. colour television signals are then investigated in detail. Some prior knowledge of colour television would be useful before reading this chapter. The book ends with a discussion of operational problems and the methods used in their solution.

This is not a book for the person who seeks only fundamentals; it is a comprehensive analysis of two methods of instrumenting the same principle of video tape recording. It praises the advantages but does not adequately describe the disadvantages—a knowledge of which is essential to the understanding of present and future developments.

To the reader who is already familiar with either an Ampex or an RCA video recorder this book will introduce alternative techniques used in monochrome and colour television recording. To the reader who knows little about the subject this book will be an excellent introduction, and could provide him with sufficient confidence—and knowledge—to impress any appointments board.

W. SILVIE

Systemtheorie für Regellose Vorgänge

(System Theory for Random Events)

By H. Schlitt. 344 pp. 166 figs. Medium 8vo. Springer Verlag, Berlin. 1960. Price DM 49.50.

THE characteristics of transmission systems are examined within the scope of the classical system theory by means of simple test signals, like standard step, standard pulse and sine wave, which can readily be described analytically. However, the actual input quantities cannot in general be described by such simple functions and, particularly when designing systems for optimum operation, the random character of the signals has to be taken into account.

The principles of the statistical signal theory as applied to the description of stachostical events are discussed in detail in this book, and a fusion with the classical system theory leads to the posing of questions characteristic to this modern field. It is hoped that the book will contribute to the closing of the gap which existed for years in German publications on statistical methods. Its broad layout addresses itself particularly to engineers, physicists and students in their later years of study, who are engaged in the analysis and synthesis of transmission and control problems in the fields of communications, control engineering, information theory and the study of communications.

Radio Aids to Civil Aviation

Editor, R. F. Hansford. 623 pp. 260 figs. Royal 8vo. Heywood & Co. 1960. Price 126s.

THIS book is for both the system engineer and the operational specialist concerned with the application of radio to civil aviation. Groups of experts have contributed chapters which survey the operational problems and the basic principle of radio systems. The first 130 pages contain an introduction to the problems facing civil aviation, followed by a résumé of radio propagation fundamentals and radar principles; basic aerial theory, the effects of the atmosphere and the ionosphere, error distributions and the basic radar equations are included. The thirty pages devoted to communications systems deal with air-ground radiotelephony with short descriptions of airborne equipment; future developments are briefly covered with some interesting comparisons between binary data link, teleprinter and speech in terms of bandwidth requirements for a high-density a.t.c. area.

A comprehensive discussion of 245 pages on 'En Route Aids' includes a full treatment of Decca and Dectra; well-established systems such as Radio Ranges, Consol, d.f., v.o.r., Gee and Loran are adequately described; competitors for the 'ultimate' long range aid such as Delrac and Navarho are included, as also are radio altimeters, airborne radar and Doppler navigation. A chapter on 'Aids to Air Traffic Control' considers traffic congestion as a queueing problem and gives examples of surveillance and height-finding radars, secondary radar systems and tracking and storage devices which can be used for the acquisition and display of aircraft positional information. In Chapter 6, brief descriptions of i.l.s., g.c.a. and 8mm radar are interspersed with discussions of the operational problem associated with approach, landing and surface movement. The seventh chapter, on 'Weather Radar' presents the theory of radar detection of precipitation and describes storm detection equipment and the interpretation of radar responses. The system design for a Radar Link is followed through in Chapter 8 and the book concludes with a review of present trends.

There are few misprints or mistakes; on page 383, the vertical polar diagram at Fig. 6.10 for an equisignal glide path is not in accordance with practice or with Fig. 6.11 and one is puzzled by the statement that the "equisignal glide path is not so stable as the null reference as regards course angle and width, being, therefore, more difficult to monitor". An Appendix gives extracts from I.C.A.O. Annex 10 but unfortunately the illustrations are from an early edition and do not always correspond with the text. There are useful graphs, abacs and bibliographies; the book is well produced and altogether it is both instructive and enjoyable to read.

L. J. BRAYBROOK

Dictionary of Automatic Control

By R. Bibbero. 282 pp. Crown 8vo. Reinhold Publishing Co., N.Y and Chapman and Hall Ltd. London. 1960. Price 45s.

THIS is an encyclopaedic dictionary of automatic control terms. It provides a condensed discussion of each topic, including applications and related subjects. The book covers control theory and basic concepts, computers and data processing, industrial machine and process control, aircraft and missile control and telemetering, and control components and design factors.

Annual Review in Automatic Programming, Vol. 1

Edited by R. Goodman. 300 pp. 9 figs. Royal 8vo. Pergamon Press Ltd. 1960. Price 63s.

THE book is the record of eighteen papers which were read at the Working Conference on Automatic Computers organized by the Department of Mathematics at Brighton Technical College. It is intended that the book shall be the first of an annual series reviewing current developments in automatic programming for digital computers.

The opening address by the Director of Studies at the Conference refers to the classical work of Turing on computability which may be regarded as the logical justification for any system of automatic programming. Succeeding papers can be divided roughly into two classes: those dealing with automatic

programming in general, and those applying to particular systems.

The general papers deal with such various topics as future trends, problems of a universal autocode, business applications, and machine tool control. A paper on the philosophy of programming deals in an amusing way with some important aspects of automatic coding.

The remaining papers deal with particular autocode systems and are a little detailed for the general reader. Autocodes are described for a wide range of machines including PEGASUS, MERCURY, and DEUCE, scientific applications, and IBM, UNIVAC, business applications. While it is obviously essential that descriptions of particular autocodes should be included in a volume of this nature, it seems likely that these papers will be of most use to the specialist in a particular machine.

The book is concluded by four appendices of which the first consists of Turing's original papers on mathematical machines and computable numbers. Other than for historical reasons it is a little difficult to see why these have been included, since the papers are only of interest, indeed comprehensible, to the specialist, and the relevant conclusions have been given in the opening paper. Appendix two is the preliminary report of ACM-GAMM Committee on an international algebraic language, Appendix three is a useful bibliography on automatic coding, and Appendix four is a list of participants of the Conference.

P. L. OWEN

Understanding Microwaves

By V. J. Young. 292 pp. 159 figs. Demy 8vo. Chapman and Hall Ltd. 1960. Price 32s.

THIS book is intended to present material which will form a basis for understanding microwave radio and radar. The book makes no claim to cover the field completely as it exists today but material has been chosen which it is believed will aid those who have not yet considered radio waves shorter than 10 centimetres.

Cermets

Edited by: J. R. Tinklepaugh and W. B. Crandall. 239 pp. 103 figs. Medium 8vo. Reinhold Publishing Corporation. 1960. Price 76s.

THE material presented in this book includes both oxide and carbide-base cermets as they apply to high-temperature applications. Considerable space is devoted to the physicochemical aspects of cermets so that the reader may become acquainted with the relationships between ceramics and metals which govern the selection of materials and the properties obtained.

Twenty-three contributors, cover the fundamental aspects, forming and processing, testing and applications of these increasingly important high-temperature materials.

The book will be of interest to the metallurgical, ceramic, aircraft, chemical and electronic industries as well as to scientific engineers who require accurate information on cermets.

Ultrasonics

By B. Carlin. 304 pp. 259 figs. Medium 8vo. McGraw Hill Publishing Co. Ltd. 1960. Price 89s.

IN the preface to the first edition, published in 1949, the author stated that the book was intended primarily to cover the engineering aspects and applications of ultrasonics. This it did very successfully, and the second edition follows the same policy, with even more emphasis on the practical side. Some of the more academic sections have been omitted altogether and considerably more information is given on applications.

The book begins with a short introduction to ultrasonic theory. This is followed by a comprehensive treatment of the generation of ultrasonic vibrations, principally by piezo-electric and magnetostrictive methods. A new chapter on measurement techniques has been added, and there is now good coverage of power equipment for generation, and of non-destructive testing of materials. The discussion of applications is preceded by a new and worthwhile summary of the effects of ultrasonics in physical, chemical and medical terms.

Apart from the reporting of errors or obscurities, which in this book are insignificant, any criticism must of necessity only reflect the reviewers personal opinions. As an example, it is felt that the author has retained too much of the first edition treatment of quartz. This is at the expense of information on the more recently developed ceramic materials which have by now almost entirely superseded quartz. However, a more general criticism is that although the book is very easy and pleasant to read, and it could well be read through by everyone entering the field, it is not easy to use as a reference book. There is unfortunately no bibliography and the many excellent tables can be difficult to locate. The headings under which the different subjects are discussed can also sometimes be misleading. Thus "Signalling in the Ocean" would not normally be looked for under the heading "Non-destructive Testing".

P. BAXTER

Semiconductor Technology

Edited by G. K. T. Conn. 74 pp. 75 figs. Crown 4to. Butterworths Scientific Publications. 1960. Price 10s. 6d.

THIS book is compiled from a series of papers revised and reprinted from *Research*. It consists of a number of articles on the preparation of pure materials and on controlled alloying. Attention is given to transistors and to the problems of handling power. The parameters which determine optical behaviour are discussed in general terms; this is followed by an article on the design, manufacture and testing of infra-red photocells as an example.

The Hall Effect and Related Phenomena

By E. H. Putley. 263 pp. 150 figs. Demy 8vo. Butterworth & Co. Ltd. 1960. Price 50s.

IN 1897 E. H. Hall of Harvard discovered that when a conductor carrying a current is subjected to the action of a magnetic field at right-angles to the current, an e.m.f. is produced across the conductor in a direction mutually orthogonal to the current and magnetic field. Owing to imperfect ideas concerning the structure of conductors, the effect was little more than a laboratory curiosity for several years after its discovery, but since the beginning of the century it has been increasingly applied, firstly by Königsberger and then by Baedeker and others to the systematic study of semiconductors. This acceleration of interest arises from the fact that the Hall effect is able to distinguish between ionic and electronic conduction, allows the number of current carriers per unit volume to be determined, and also whether they are positively or negatively charged. Today the Hall effect has become one of the most powerful and elegant tools for studying the electronic properties of semiconductors.

Dr. Putley, himself a substantial contributor to the subject, has performed a valuable service in collating the scattered literature of the subject in a volume of the well-known Butterworth semiconductor monograph series. The author's preface states that, although the book was based on an article published in the TRE Journal, he has endeavoured to bring the original article up-to-date with extensive discussions on magnetoresistance, thermoelectric and other galvanomagnetic effects. It is the opinion of this reviewer that he has succeeded in his object. The five chapters of the book are well planned with copious references and diagrams. The initial section gives a balanced review of theories of electronic conduction with accounts of early and recent work on silicon and germanium. Chapter II gives practical details of the various measurements met with in the evaluation of galvanomagnetic effects. When very detailed measurements are required, as in studying the dependance of Hall coefficient upon magnetic induction, the author's automatic measuring system has much to commend it in reducing the time required to take observations, and the elimination of a considerable amount of tedious labour.

Of especial interest to the reviewer was the last section of this chapter dealing with practical applications. Since the Hall voltage is a product of specimen current and applied magnetic field we have the basic requirements for a modulator or analogue multiplier. This is of importance in the telecommunications field where a need has long been experienced for a distortionless pure product modulator with absence of harmonic sidebands and carriers, and the 100 per cent modulation inherent in the device implies that all the available power is confined solely

to sum and difference frequencies. Hence double sideband suppressed carrier and single sideband generation become feasible.

A theoretical treatment of thermal conductivity and thermo-electricity together with the generalized equations of transport properties and magneto-resistance effects is given in Chapter III followed by a fairly exhaustive account in the succeeding chapter of the behaviour of typical semiconductors in which recent work on quantum effects in large magnetic fields is adequately surveyed. The concluding chapter represents a summary of the electrical properties of group IV B elements, III-V compound lead sulphide, selenide and telluride, II-VI compounds and other elementary and compound semiconductors.

A few errors have crept in, mostly of a mathematical character and associated with Chapter III. For example, equation (3.18) on page 172 appears to have lost a v_x and a new symbol V_x has been introduced on page 74 in discussing the contribution that an electron of energy ϵ makes to the thermal energy current. A slight error which seems to have passed proof reading was an erroneous abscissa marking in fig. 5.12, page 216. However, these faults are slight blemishes on an otherwise excellent work and it is believed that this book will have a special appeal, not only for the many workers concerned with semiconductor research and development, but will also serve the needs of those in other branches of solid state physics and be of great interest to honours students.

E. COHEN

Induction Heating

By P. G. Simpson. 295 pp. 170 figs. Medium 8vo. McGraw Hill Ltd. 1960. Price 89s.

THIS book at the present time is occupying an exclusive position, being almost the only text in print covering the science, or perhaps art of "Induction Heating".

The subject matter embraces Theory, Heat and Metallurgical Effects, Applications, Coil Design, Methods of Power Generation and Auxiliary Equipment over the frequency range from supply mains frequencies, through machine frequencies to radio frequencies. A two-page Appendix has been added on the rapidly advancing subject of Zone Refining by R. F. Heating.

The general style of writing tends to make the book more suitable for the physicist than for the less scientific user, or applications engineer; however, this impression is somewhat reversed on reading the final chapters describing supply mains frequency heating and machine frequency billet heating, where the author is drawing on his extensive practical experience in this field, in the United States. Worked examples on many design problems are given and will assist the less technical reader in solving his own particular problems.

The reviewer would like to suggest that for future reprints, the information contained in the text should be collected and condensed, to provide a quick reference appendix for the user of "Induction Heating Equipment". Perhaps also sections could be included in the use of h.f. energy in the growing fields of vacuum metallurgy and processes related to atomic energy.

In conclusion the reviewer would like to congratulate Mr. Simpson on the skilful reduction of many trial and error problems to scentific formulae, and presenting these in a readily digestible form.

W. D. WILKINSON

The Antenna

By L. Thourel. 407 pp. 272 figs. Medium 8vo. Chapman & Hall Ltd. 1960. Price 70s.

THIS book is a translation from "Les Antennes", first published in 1956 and based on a course at the Ecole National de l'Aviation Civile. It is intended as "a manual for use in planning an antenna system ... a précis of information on antenna techniques", with only the irreducible minimum of mathematics. The author hoped to fill the regrettable gap in French works on aerials: the publishers of the translation, in hoping to fill "the regrettable gap in the literature", make a much wider and less easily justified claim.

Certainly no previous work in English has so wide a range. After two introductory chapters, the book proceeds from a wavelength of 20 000 metres in chapter three to v.h.f. and u.h.f. in chapter nine. Six chapters on microwave aerials follow, and one, rather misplaced in the frequency scale, on frame aerials. There is a useful twenty page appendix on transmission lines, and, finally, rather scrappy subject and author indices. Very new or highly specialized techniques are deliberately excluded.

There are some very good sections in the book, notably that on double curvature reflectors, as one would expect from a French author, and on the tolerances allowable in a parabola. But the text is uneven, and judged as a replacement for the American texts by Kraus and by Silver, (it leans heavily on these for its references), the book fails on two main counts. It lacks balance (there are twenty-two pages on rhombic arrays, whereas section 13.6, on cosecant squared aerials, has three poor diagrams out of five, half a page on the defects of a barrel aerial, two mis-prints and a gross mis-translation, all in two pages), and it lacks sufficient practical data. Such examples as are given often lack details of size, frequency and bandwidth, so that it is impossible to judge to what extent an array will fulfill its theoretical promise.

The non-specialist reader, who might wish to have all his aerials in one volume, will find that the minimum of mathematics is by no means negligible, and that the frame or boxes, used to show practical formulae as distinct from involved theory, are few and far between. He will be irritated by the poor English of the translation, which is sprinkled with misprints and Gallicisms ("ondulations", "annulation"), and he may be mislead by "aperture" as applied to a beam. This is usually beamwidth "in the the Anglo-Saxon literature" (p. 252). He will feel, and rightly, that if this book were all as good as its best, and if it were translated anew, it might well be worth seventy shillings to a wide variety of readers.

M. J. B. SCANLAN

Techniques of Non-Destructive Testing

Edited by C. A. Hogarth and J. Blitz. 216 pp. 132 figs. Medium 8vo. Butterworths Publications. 1960. Price 40s.

MOST of the chapters in this book are self-contained accounts of the theory and practice of electrical, magnetic, mechanical, and visual testing techniques. Other chapters devoted to ultrasonic, radiological and thermal comparator methods are supported by thorough introductions to their scientific backgrounds, which help the readers to gain full value from the use of these new and important methods of non-destructive testing. A final chapter outlines the manner in which many of the techniques are in current use within a government establishment.

EE 32 117 *for further details*

CHAPMAN & HALL

Electronic Maintainability

Edited by

F. L. ANKENBRANDT

Distributed in association with Reinhold Publishing Corporation for Engineering Publishers, N.J.

This book, based on the Third Electronic Industries Association Conference on Maintainability of Electronic Equipment, contains an authoritative discussion of the developments which have been changing maintainability from the vaguely practised art of yesterday to the rigorous science of today. The subject matter ranges from the maintenance problems of space flight to the determination of adequate working space for electronic technicians.

Illustrated 80s. net

37 ESSEX STREET, LONDON, W.C.2

LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Selecting Limit Transistors for Tuned Amplifiers

DEAR SIR,—This note describes an effective and simple method of selecting and defining limit transistors in tuned amplifier applications, based upon a measurement[1] of f_T. At present it is very difficult to check the tolerance design of high frequency transistor amplifiers for the following reasons:

(1) The only satisfactory way of specifying present-day transistors with their superior frequency response is to quote the maxtrix parameters (in particular Y parameters). Since the four Y parameters are complex numbers the upper and lower limits could not be stated without considering the real and imaginary parts separately i.e. eight upper and eight lower limits.

(2) On present day transistors the reverse transconductance y_{12} is so small that it is hardly measurable, at high frequency on a production basis. If manufacturers cannot specify this parameter and its limits with extreme accuracy, it is impossible for a designer to assess the stability of a transistor amplifier.

(3) Experiment has shown that very little can be learnt about the spread in high frequency performance by inspecting parameters measured at d.c. For instance, there is in general no correlation between the spread in h_{FE} and the spread in high frequency performance.

(4) Even if the four Y parameters with limits are quoted, it is of little practical use to analyse the 'worse case'. Apart from the cumbersome mathematics that will arise, the results will be without meaning unless the statistical correlation between the (sixteen) limits of the Y parameters is known.

Having considered the above facts, an engineer usually designs his equipment around typical transistors and tests the stability etc. with limit ones. He is then faced with the dilemma of defining and selecting these typical and limit transistors.

It is in this respect that the method of selection to be described, can be of assistance.

It has been observed that P_G is a characteristic property of some transistor types i.e. P_G is almost constant from transistor to transistor within the type (P_G is defined as the maximum matched unilateralized power gain in the common emitter configuration). If it is assumed that P_G is constant for a certain type of transistor while the associated Y parameters vary considerably, then there would be a perfect functional relationship between f_T and N, as shown in Fig. 1. The measurement of f_T is described in the literature[1] and N is the ratio of the transformer which matches Re y_{11} to the Re y_{22}. A good approximation for P_G in terms of Y or H parameters is shown in equation (1):

$$p_G = \frac{|y_{21}|^2}{4 \operatorname{Re} y_{11} \operatorname{Re} y_{22}} = \left(\frac{|h_{21}| \cdot N}{2}\right)^2 \quad \ldots\ldots\ldots\ldots (1)$$

Provided that the frequency of operation f_o is greater than the common emitter current gain cut-off frequency

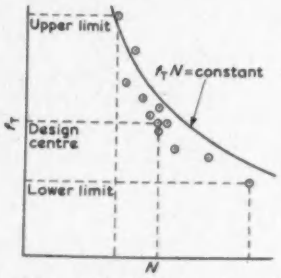


Fig. 1. The relationship between f_T and N

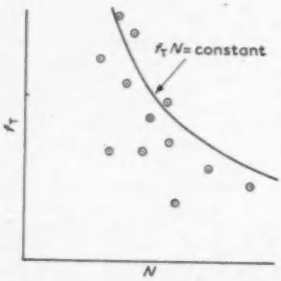


Fig. 2. Relationship when P_G is subject to considerable variation

f_{hfe}, then h_{21} appears as in equation (2). It can be shown[1] that for a given d.c. working point N is practically constant in the frequency range $f_o > f_{hfe}$

$$f_o \cdot |h_{21}| = f_T \quad \ldots\ldots\ldots\ldots (2)$$

Combining equations (1) and (2) the functional relationship (a rectangular hyperbola) between f_T and N is given in equation (3).

$$f_T \cdot N = 2 f_o \sqrt{P_G} = \text{constant} \quad \ldots (3)$$

Practical tests on various types of transistors whose P_G is fairly constant, indicate that a correlation similar to the above does exist. Typical findings are shown in Fig. 1 together with the 'ideal' correlation curve. Transistors whose P_G is subject to considerable variation, show a weaker correlation (more dispersion) as in Fig. 2. (These tests were carried out by measuring f_T and the Y parameters at a predetermined working point and $f_o \gg f_{hfe}$.)

The design of a narrow or wide band amplifier is always initiated around the typical (statistical mode) value of N. The stability and marginal performance can then be tested with limit transistors. Using the plot of f_T against N, the design centre can be chosen and limit transistors easily selected, if there is a strong correlation as in Fig. 1. Experiment has shown that lower limit (f_T) transistors have also the worst stability factors. In the case of a weaker correlation as in Fig. 2, the design centre and limits are not clearly defined. A spread of this nature is usually more troublesome because P_G will vary considerably in addition to N. Variations in N alone are not as serious as they appear. The mismatch loss due to variations in N is shown in equation (4), where N_o is the design centre and N_L the upper or lower limit of N.

$$\text{Loss (dB)} = 10 \operatorname{Log} \left[\frac{1 + (N_L/N_o)^2}{2\,(N_L/N_o)}\right] \quad \ldots\ldots\ldots\ldots (4)$$

If N_L is equal to twice N_o the mismatch loss is <2dB. A very weak correlation between f_T and N suggests that the transistors under test are a mixture of types. This may be due to some method of selection used by the manufacturer or a production process which could have tighter control.

In summing up, it may be said that by discovering a simple correlation between y_{21}, y_{11} and y_{22}, some problems outlined at the commencement of this note have been avoided and a practical testing method evolved.

By plotting and scrutinizing the correlation between f_T and N a designer can select limit and typical transistors and also gain insight into the nature of the product.

From the manufacturers' point of view the method outlined in this note suggests that the spread on the frequency performance of a transistor can be controlled by only one variable. The inclusion of upper and lower limits of f_T on data sheets therefore seems desirable.

Acknowledgments are due to the management of Semiconductors Ltd for permission to publish this note.

Yours faithfully,

J. R. JAMES,

Semiconductors Ltd, Swindon.

REFERENCE

1. JAMES, J. R., BRADLEY, D. J. Transistor Frequency Response. *Electronic Technology*, 38, 80 (1961).

Stabilized Voltage Supplies Using Transistors

DEAR SIR,—It has come to my notice that in Fig. 1, page 758, December 1960, the 1S111 diode in the top left corner (the starting diode) is shown connected the wrong way round. Its positive end should

go to the −27·6V rail. This is made clear in the text, the diode becoming cut off as the convertor starts operating, raising the voltage at the lower end of the diode to over 30V. I would also point out that in this original circuit, the reference diode chain shown to consist of four OA7 207's was, in fact, two OAZ 207's and two OAZ 201's in series.

The unit would still operate, however, with the four OAZ 207 as shown, though the 'set output' control would probably be hard at the bottom end.

I apologize for these errors.

Yours faithfully,

P. G. WRIGHT,
Smith's Aircraft Instruments Ltd,
Cheltenham, Gloucestershire.

Transistor Charge-Control Parameters

DEAR SIR,—We were interested to read in your issue of October 1960 of Signor Ercoli's method of measuring τ_c without prior determination of β_o.

There is general agreement that methods of measuring charge parameters, not involving the interpretation of a waveform, would be desirable.

Methods which we have developed of measuring τ_s and τ_{co} may therefore be of interest as the result is presented as a meter indication and there is no manual adjustment.

The basis of the methods is a circuit due to R. A. Hilbourne, of G.E.C. Ltd, originally used for diode measurements[1] and adapted by him for τ_s measurement.

To the best of our knowledge correlation with the oscillographic methods was only fair and objections have been raised[2] to the measurement condition, the transistor being strapped as a diode with collector and emitter common.

Accordingly our circuits provide for defined direct currents and collector-emitter voltage, conforming as closely as possible to those in the corresponding oscillographic methods.

Considering the circuit for τ_s (Fig. 1), in the absence of pulse drive the transistor is heavily saturated and all of I_b is taken to be saturation current as it is in the corresponding oscillographic circuit (Fig. 2) (due to Sparkes). V_{ce} adjusts itself to a low value.

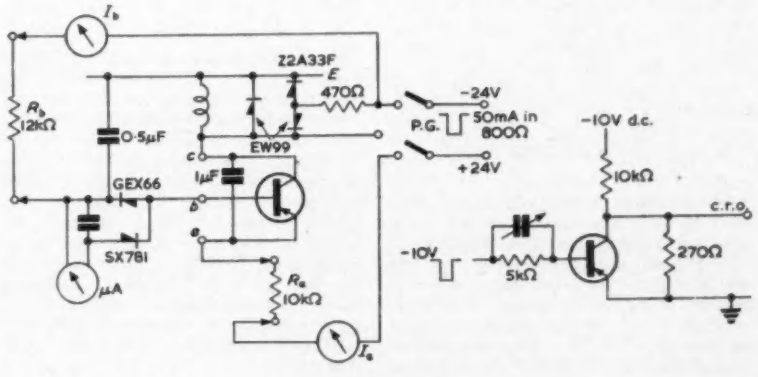


Fig. 1. (left). Circuit for measurement of τ_s

Fig. 2. (right). The corresponding oscillograph circuit

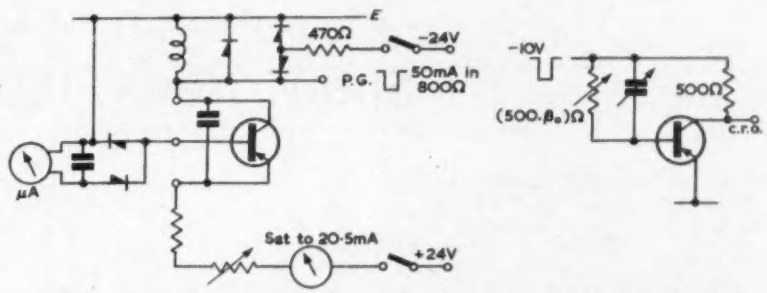


Fig. 3. (left). Circuit for measurement of τ_{co}

Fig. 4. The corresponding oscillographic circuit

The pulse duty ratio is low (typically 4μsec at 4kc/s or up to 10μsec at 1kc/s). The base charge is alternately built up to equilibrium (during the off period) and transferred (during the negative pulse) to the reservoir capacitor and microammeter. The microammeter reading I_s is thus equal to the product of the transferred charge and the repetition frequency. Hence

$$\tau_s = \frac{I_s}{f I_b} \text{ since } \tau_s = Q_s/I_b$$

The τ_{co} circuit is similar (Figs. 3 and 4). In this case, by incorporating the main features of a well-known method of measuring β_o the base current automatically assumes the value corresponding to the brink of saturation at $I_c = 20{\cdot}5$mA. (This is taken to be a good enough approximation to $I_c = 20$mA.)

The r.f. choke (0·8 to 1·2mH) is essential in this circuit in order to make the collector potential zero for a substantial period prior to each negative pulse.

All types of germanium pnp junction transistors so far tested have shown agreement between these 'stored charge' methods and their oscillographic counterparts which is good enough for many engineering purposes without applying a scaling factor. In some cases agreement is outstandingly good as the accompanying scatter diagrams show (Figs. 5 and 6).

In the τ_s case the measures taken to make the collector current and potential conform to the comparable oscillographic case appear to have only a marginal effect on results with the majority of transistors, little change being observed

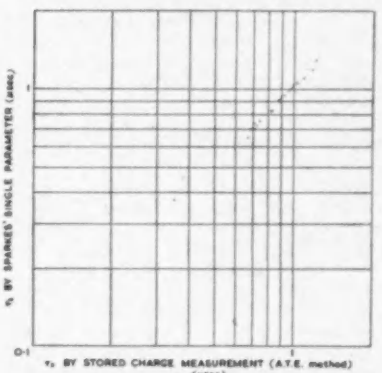


Fig. 5. Correspondence between τ_s measurements by stored charge and oscillograph methods for 2N583 (*mean* $y/x = 1{\cdot}04$)

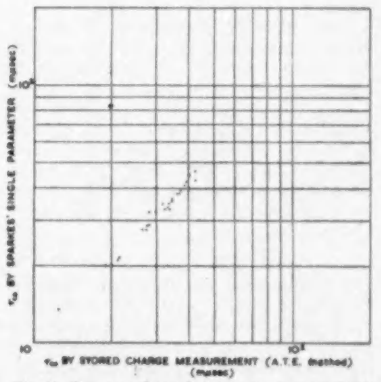


Fig. 6. Correspondence between τ_{co} measurements by stored charge and oscillographic methods for 2N583 (*mean* $y/x = 1{\cdot}02$)

if a collector and emitter are short-circuited as in Hilbourne's method.

In the τ_{co} circuit the corresponding measures are, of course, fundamental to the operation.

An article describing the above technique in more detail will appear in the April 1961 issue of the A.T.E. Journal.

Yours faithfully,

R. C. WINDSOR,
Automatic Telephone & Electric Co. Ltd,
Liverpool.

REFERENCES

1. SPARKES, J. J. A Study of the Charge Control Parameters of Transistors. *Proc. Inst. Radio Engrs. 48*, 1703 (1960).
2. SCARR, R. W. A. The Switching Performance of Alloy Junction Transistors. *Appl. Rep. S.T. & C. Ltd.* Part I, pp. 11 & 12.

Short News Items

A Commonwealth Technical Training Week Scheme has been proposed by H.R.H. the Duke of Edinburgh in his capacity as President of the City and Guilds of London Institute. The principal objects of the scheme are to stimulate awareness of the responsibility of the community towards young people entering employment; to stress the importance of schemes of induction and training, both for the benefit of individual firms and in the interests of the young people themselves; to give increased opportunity to young people to learn of the opportunities available for training and education and generally to emphasize the significant place of the young worker in society. The Week is intended to cover all forms of training for employment. In Great Britain a central organization has been set up and the week, 29 May to 4 June, 1961, has been selected for Great Britain's Week. Full particulars can be obtained from the Secretary (C. B. McAlpine, C.B.E.) Commonwealth Technical Training Week, City and Guilds of London Institute, 76, Portland Place, London W.1.

The Scientific Instrument Manufacturers' Association of Great Britain has appointed Major F. D. Outridge, R.A. (Retd), as assistant to Capt. R. A. Villiers, C.B.E., Director of the Association. In his capacity as assistant to Capt. Villiers he will be particularly responsible for the publicity and exhibitions of S.I.M.A. in the U.K. and overseas, and will also act in a secretarial capacity to the main Committees.

A Symposium on Electronic Aids to Banking, organized by the Committees of the Electronics and Communications and Measurement and Control Sections of the Institution of Electrical Engineers with the co-operation of the Electronics Sub-Committee of the London Clearing Banks and under the *aegis* of the British Conference on Automation and Computation, will be held at Savoy Place on 17 and 18 January, 1962. It is designed to interest engineers engaged in the development, design and manufacture of equipment and those who are concerned with its use. The symposium will cover the following subjects: (1) Users' problems, (2) Document handling, character reading, automatic reading and sorting of cheques, (3) Accounting aspects and the use of computers, (4) Communication aspects, e.g. links between branches and the central unit, and closed circuit television. The submission of papers on all aspects of the topics set out above is invited. These should be as concise as possible without loss of essential information, but in any case they should not exceed 8 000 words. The Organizing Committee invite all authors to forward synopses, of not more than 250 words, of their papers to The Institution by the 14 April, 1961. Completed manuscripts should be submitted before the 31 August, 1961.

The General Post Office has extended the existing United Kingdom h.f. long-range radio-telephone service from ships at sea to telephone calls from aircraft as from the beginning of last month. The service will be available to any airline or privately owned aircraft, subject to satisfactory tests, but in the interests of safety any airline wishing to take part is required to give an undertaking that an uninterrupted effective watch on the a.t.c. channel will be kept at the same time as the telephone calls are made. Some European countries and the American Telephone and Telegraph Company operate a similar service.

The University of Oxford, Department of Education led by its director, Mr. A. D. C. Peterson, is to investigate the reasons for comparatively fewer students electing to read for technological qualifications in this country than in the U.S.A. and Russia. This research, which will occupy a period of 2 years, has been made possible by a grant of £2 500 to the University from the Capitol Radio Engineering Institute of Washington, D.C., through their International Division, C.R.E.I. (London).

The Electronic Engineering Association at its recent Annual General Meeting has elected as chairman Dr. D. N. Truscott (General Electric Co. Ltd.), in succession to Mr. L. T. Hinton (Standard Telephones & Cables Ltd.). Mr. W. D. H. Gregson (Ferranti Ltd.) was elected vice-chairman in succession to Mr. R. R. C. Rankin (Mullard Equipment Ltd.).

The Annual Dinner of The Institution of Electrical Engineers was held at Grosvenor House, London, on Thursday, 23 February, when the President, Sir Hamish D. MacLaren, K.B.E., was in the Chair. The principal guest was the Rt. Hon. Richard Wood, M.P. (Minister of Power) who proposed the toast of The Institution, to which the President replied.

The Institute of Radio Engineers, Inc. of New York has been awarded a grant of $10 000 by the National Institute of Health and a grant of $5 000 by the National Science Foundation for the support of the 4th International Conference on Medical Electronics which is to be held on 16-21 July, 1961, at the Waldorf Astoria Hotel, New York, N.Y.

The BBC has installed two new 100kW short-wave transmitters at its External Services transmitting station at Rampisham, Dorset as part of a long-term plan for the modernization and re-equipment of BBC short-wave transmitting stations, where most of the installations have now been in service since 1940. Special attention has been given to the problem of providing a rapid change of operating frequency. With the new equipment a frequency change can be carried out in a few seconds by a simple switching operation which has been made possible by the provision of two radio-frequency amplifiers for each transmitter. In addition to changing the transmitter frequencies at scheduled intervals it is necessary also to switch the transmitter to different aerial arrays which are designed to radiate in a particular waveband and on a certain bearing. For this purpose BBC engineers have developed a new form of electro-pneumatic switch which is remotely controlled from inside the station and enables the output of a transmitter to be connected to a selected aerial feeder.

C.A.V. Limited, the world's largest manufacturer of diesel fuel injection equipment, has placed an order with Leo Computers Limited for data processing equipment to be delivered at the end of next year. This will include a LEO III fully transistorized digital computer having a high-capacity quick-access magnetic core store in place of the more usual drum store, and multi-channel concurrent input and output facilities. The computer will be installed in the C.A.V. main works at Acton and will handle payrolls for all personnel there and at the Rochester and Sudbury factories of the Company. A number of commercial applications are also planned. In addition, the LEO III computer will be used for research work and to accelerate design calculations. Similar work for C.A.V. was first carried out by hiring time on the LEO I computer at Cadby Hall in 1955.

Ferranti Ltd announce that during the past six months orders worth £350 000 have been received for their machine tool control systems and inspection machines from companies in the United States, Europe and the United Kingdom. Over 50 per cent of the equipment sold during this period has been to the United States. This is a result of the agreement entered into with the Bendix Corporation for the sale and service in the U.S.A. of the Company's transistor hydraulic continuous-path machine tool control equipment, numerical positional control equipment and inspection machines.

The Council of the Institution of Electrical Engineers has elected to Honorary Membership The Rt. Hon. The Lord Nelson of Stafford, Chairman of the English Electric group of Companies and Past President of the Institution, in recognition of his outstanding contribution to the development of electrical science and engineering, and for his many services to the Institution. The Council has also made the Thirty-Ninth Award of the Faraday Medal to Julius A. Stratton, Sc.D., LL.D. for his notable contributions in the fields of technological education and research in radio communication. Dr. Stratton, who has been associated with the Massachusetts Institute of Technology since 1924, has been its President for the last three years.

Westminster Bank Limited is installing in its Clearing Department a new electronic cheque and document sorter capable of sorting cheques of mixed or uniform size at the rate of 750 a minute. The sorter will initially be used to carry out experiments in the electronic sorting of cheques received from the Clearing Department for despatch to the Bank's branches. The loading platform holds up to 2 000 cheques and more can be added while the machine is running, and the number of cheques passed to each of the 12 sorting bins is recorded. The sorter which works on a magnetic character recognition system has been supplied by the National Cash Register Co. Ltd.

Royston Instruments Limited of Byfleet, makers of the Midas Magnetic Tape Flight Recording system, have granted a manufacturing licence to Lockheed Aircraft Services of California, under which the American company will make and market the equipment in the Western Hemisphere and Australasia. This licence is an extension of a previous agreement between the two companies, made in April last year, when Lockheeds were appointed agents for Midas. Plans are afoot in the U.S.A. to fit the British-designed flight recorder in American aircraft and there is also strong U.S. military interest in the equipment. The Midas system provides a wide variety of data recording and handling equipment and is considered by the Americans to be at least three years ahead of any being developed in the field.

An Exhibition was held last month by the Semiconductor Division of Mullard and was devoted to the use of semiconducting devices for industrial purposes. Some 150 exhibits from about 100 electronic firms were displayed, all using semiconductors; exhibits ranging from industrial control systems; computers; medical electronics; r.f. and a.f. communications equipment; test gear; measuring instruments, to sub-units such as power supplies, amplifiers, convertors, and regulators.

The Harwell Reactor School will hold the next two-week course for senior technical executives from 8-19 May. For the first week, participants will be at the School and for the second, at Durley Hall, Bournemouth. The course is planned to give senior industrialists with a technical background an overall appreciation of the problems of reactor technology. The lectures cover the physical, metallurgical and engineering problems involved in the design of power reactors and the chemical problems of fuel and effluent processing. The fee for the course is fifty guineas (excluding accommodation). Details of this and other courses can be obtained from: The Manager, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire.

The Electrical Research Association has announced the composition of its Divisional Committee No. 3—Switchgear and Transformers for Power Supply—which recently held its inaugural meeting. Dr. H. G. Taylor, Director of the Electrical Research Association, is an ex officio member of the Committee, and the secretary is Major E. D. Gardner of the Electrical Research Association.

Messrs. Maurice Guerdat, rue de Nidau 11, Bienne, Switzerland, have formed a subsidiary company—*S.A. pour l'Achat et la Vente d'Appareils Electroniques* for the import and the distribution of electronic test and control equipments for the watchmaking and precision engineering industries.

Marconi's Wireless Telegraph Co. Ltd have received an order through SIEDMA, their French aeronautical agents, from the Centre de'Essais en Vol at Istres (France) for the supply and installation of a Marconi type S232/2 crystal-controlled 50kW 50cm radar. This is in the nature of a 'repeat order', as an S232 has been in use at another Centre d'Essais en Vol airfield at Bretigny for some few years past. The characteristics of the S232/2 are such that it can be used simultaneously for long range surveillance and for close control of aircraft within the airport terminal area under all conditions of weather. Because all airport radar requirements except that of p.a.r. (Precision Approach Radar) are met by the one equipment, it provides a very attractive saving in capital and operating costs as well as an economy of skilled man-power. The company has also received an order to the value of over £1·7M from the Royal Swedish Air Board for the supply of electronic equipment for defence purposes. At the centre of the Marconi system is a very high speed computer which solves a large number of interception problems simultaneously and enables the defence weapons—fighters, guided missiles and other defensive devices—to be brought into action at precisely the right instant. Black and white television and colour projection together with automatic information-dissemination techniques also play a vital part in the overall system. Approximately 500 000 transistors and diodes and 15 000 valves are incorporated in the equipment.

The Conservators of the River Medway are modernizing their services on the Medway with a Decca Type 32 Harbour Radar and three 16in display consoles. V.H.F. radio communication equipment is being supplied by Pye Telecommunications Ltd and the whole system will be integrated with the Medway Port Operations and Information Service. Due to the increased tanker traffic and the number of dry cargo vessels coming into the river, the Medway is the fifth busiest port in the United Kingdom, excluding British Transport Commission ports. As an interim measure, the Conservators of the River Medway have recently established a Port Operations and Information Service at Sheerness, with Headquarters in the Signal Station, Garrison Point Fort. The station is equipped with Pye v.h.f., r.t. equipment, and is served by a patrol launch fitted with a Decca D 404 marine radar and v.h.f., r.t.

A second EMIDEC 2400 data processing system has been ordered from EMI Electronics Ltd. for the use of the Royal Army Ordnance Corps. It will be installed at the R.A.O.C. Depot at Donnington, to control stocks of technical stores. The first EMIDEC 2400 computer is scheduled for delivery this summer to the R.A.O.C. Depot at Chilwell, for controlling the Army's stocks of motor transport spares. When both computers become fully operational, 85 per cent of the range of items of Army Ordnance stores will be recorded and controlled by EMIDEC systems. Donnington's computer will control stock levels of 270 000 different items of technical stores, ranging from radar equipment and refrigeration plant to pistols and guided weapons. 30 000 transactions take place at Donnington, on average, every week.

The Ministry of Aviation has placed a contract with Elliott Brothers (London) Limited, a member of the Elliott-Automation Group, for experimental air traffic control equipment to be installed at the Air Traffic Control Experimental Unit. This equipment, which incorporates an Elliott '502' Computer as its central data processing unit, was the subject of a requirement which the Ministry put out to tender and the proposals put forward by Elliott Brothers (London) Limited have been accepted by the Ministry as a basis for meeting the requirement. The technical authority for the contract is to be the Ministry's Royal Radar Establishment at Malvern. It was recently announced that contracts had been placed by the Ministry of Aviation with Elliotts for the development of Training Simulators, which will also incorporate the '502' computer.

ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

(Voir page 259 pour la traduction en français ; Deutsche Übersetzung Seite 266)

DIGITAL VOLTMETER

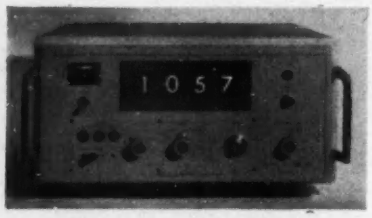
(Illustrated below)

Solartron Laboratory Instruments Ltd, Cox Lane, Chessington, Surrey

In the digital voltmeter type LM 902·2 d.c. voltages from 100μV to 1·500kV are presented as a 4 digit display in decimal form with polarity discrimination. Display is by means of optical projection and is free from the ambiguity common to some systems of digital presentation. Red and black backgrounds signify positive and negative inputs respectively.

The voltage measurements are covered in five ranges. The input impedance is 100MΩ, except on the two lower ranges, which have impedances of 1MΩ and 100kΩ. The long term accuracy is ±0·5 per cent.

The read-out time is constant at 280msec irrespective of the voltage input, which may be 'floated' up to 700V with respect to earth.



A 'check' position on the range switch permits zero setting and a calibration check. The internal Zener reference can be preset to its precise value and corrected if necessary against the built-in Weston standard cell.

Under normal (AUTO) operation voltages are measured continuously, any variations causing the instrument to display a new reading. For maximum versatility of application, the LM. 902·2 has an adjustable 'dead zone', which can (within limits) make the instrument insensitive to small changes in voltage. Thus, it is possible to obtain jitter-free readings in the presence of transients. 50c/s ripple components that may be present on the voltage to be measured can be attenuated or rejected by switching in short or long time-constants on the input circuit.

When switched to SAMPLE mode of operation a single voltage reading is taken, either by manual operation of a panel button or by remote electrical command. This reading will remain on display until a succeeding sample is taken.

Two 50-way sockets at the rear provide decimal coded digital information, polarity and print command signals suitable for feeding into a Venner TSA 65 Printer and an additional display unit.

EE 32 751 *for further details*

WIREWOUND POTENTIOMETER

(Illustrated above)

Painton & Co. Ltd, Benbridge Drive, Kingsthorpe, Northampton

The latest Bourns Trimpot, model No. 224, is being produced at the Northampton works of Painton & Co. Ltd.

This 1·25in long wirewound potentiometer operates at 175°C and is sealed against humidity, liquids and potting compounds.

A self locking 22 turn screwdriver adjustment with excellent shock, vibration and acceleration stability, and the precision wound element ensure a high level of reliability. Power dissipation is 1W at 70°C and 0·5W at 125°C. Resistance values are available up to 100kΩ.

Three types of terminal configurations are available: insulated leads, solder-lugs and printed circuit pins.

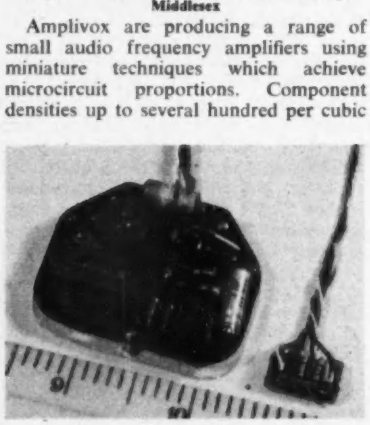
EE 32 752 *for further details*

MINIATURE TRANSISTOR AMPLIFIERS

(Illustrated below)

Amplivox Ltd, Beresford Avenue, Wembley, Middlesex

Amplivox are producing a range of small audio frequency amplifiers using miniature techniques which achieve microcircuit proportions. Component densities up to several hundred per cubic inch are obtained by using conventional wiring methods.



The larger amplifier illustrated enables a miniature magnetic microphone to be used in a carbon microphone circuit for superior intelligibility and better signal-to-noise ratio. It is available in several different forms, one of which is encapsulated and designed to meet Ministry climatic requirements.

The sub-miniature unit with a component density of over three hundred per cubic inch is a three transistor amplifier mounted on a printed circuit board that measures about 0·5in by 0·2in. The gain, which is stabilized by feedback, is 76dB and the power output is approximately 1mW into 600Ω.

EE 32 753 *for further details*

HANOVER FAIR

'Electronic Engineering' will occupy Stand 2 in Hall 13 at the Hanover Fair from 30 April to 9 May and visitors will be welcome.

6Gc/s TRAVELLING WAVE TUBE

General Electric Co. Ltd, Magnet House, Kingsway, London, W.C.2

M-O Valve Co., Ltd, a subsidiary of G.E.C., has started production on a new addition to its range of periodically focused travelling wave tubes.

It is known as the G.E.C. TWC5, a travelling wave tube power amplifier, capable of delivering 15W in the 5 925 to 6 425Mc/s band.

The G.E.C. TWC5 has been specially developed for multi-channel telecommunications systems operating in this range of carrier frequencies, although the permissible bandwidth coverage can be considerably greater.

A key feature is its easy replaceability in a periodic magnetic circuit—a notable advance over comparable valve types. By strict production control of metal and glass mechanical components, and of elaborate pumping schedules, the tube promises a long life and a high degree of reliability, and will meet the most stringent requirements of communication systems.

EE 32 754 *for further details*

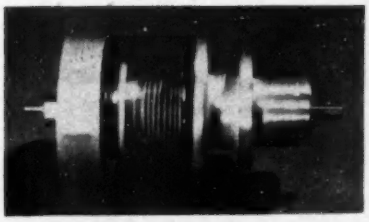
HIGH VACUUM VARIABLE CAPACITORS

(Illustrated on page 253)

English Electric Valve Co. Ltd, Waterhouse Lane, Chelmsford, Essex

The English Electric Valve Co. Ltd have announced what is probably the first British commercially available high vacuum variable capacitors. Five units comprise the range, three with capacitances of 5 to 30, 8 to 50, 16 to 80pF and two with capacitances of 5·5 to 206pF. The peak r.f. voltage is 15kV for the first three and 8 and 10kV for the other two.

By using a high vacuum as the dielectric, the spacing of the capacitor plates is reduced to about one-tenth of



that required for an air dielectric unit of comparable rating, giving a capacitor of extremely compact design. Although in some cases compactness is a major virtue in itself, particularly in airborne and military applications, the attendant advantages of reduced stray capacitance and inductance offered by the vacuum capacitor are attractive to the designers of r.f. circuits for broadcasting, commercial and industrial equipments.

The construction follows in principle that of the well-known high vacuum fixed capacitor wherein the capacitor elements are made up from overlapping concentric cylinders. The variable capacitor, however, uses a metal bellows, which forms part of the vacuum envelope, to transmit an axial motion to one set of cylinders, thus enabling the overlap to be adjusted. The processing and assembly of the metal bellows play a major part in the successful manufacture of these capacitors. A linear capacitance law is ensured by the nature of the construction except at minimum capacitance when fringe effects cause a small deviation. The capacitors, the largest of which has dimensions of only 9·5in by 3·5in, are designed to comply with the requirements of RCS11.

EE 32 755 *for further details*

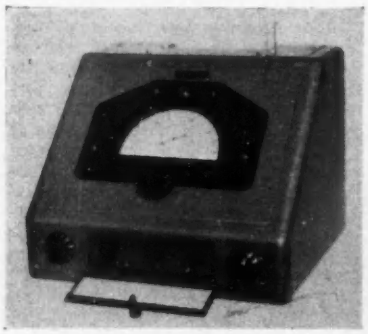
MOISTURE METER

(Illustrated below)

Kappa Electronics, 159 Hammersmith Road, London, W.6

The Kappa moisture meter type AB/55 is intended for the rapid and accurate determination of moisture content in a wide range of materials.

The instrument is a frequency-sensitive device that measures, in arbitrary units, the permittivity of the contents of a removable test cell, the permittivity being dependent upon the physical properties and moisture content of the material. A change in frequency produced by a variation in the moisture content of the sample is accurately detected by a superheterodyne circuit and is indicated on a continuous scale that is calibrated in 1 000 well-spaced divisions.



The frequency of the test circuit is selected so that readings are not affected by conductivity and a choice of cell size ensures that the sample is truly representative of the bulk.

For normal materials of reasonably constant composition and texture, the accuracy can be expected to lie within 0·05 to 0·4 in the 0 to 20 per cent: 0·2 to 0·5 in the 20 to 30 per cent; 0·3 to 0·7 in the 30 to 40 per cent; and 0·5 to 1·0 in the above 40 per cent moisture range.

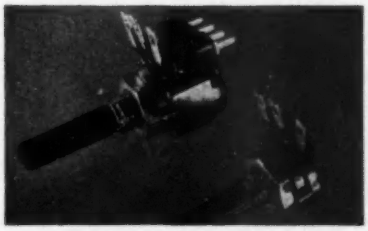
EE 32 756 *for further details*

SUB-MINIATURE POTENTIOMETERS

(Illustrated below)

Egen Electric Ltd, Charfleet Industrial Estate, Canvey Island, Essex

Designed for use in transistor circuits, this new range of Egen potentiometers incorporates many features of interest



in the field of miniaturization. Robustly constructed on a die-cast body of only ¼in diameter, these bush mounted controls have a tough moulded spindle of 3/16in maximum diameter and will be available with standard resistance values in the range 1kΩ to 3MΩ log. or linear law. Lower values can be made to special requirements. Two models will be manufactured initially, type 363 non-switch and type 365 with 50V 150mA d.p.s.t. switch, both with standard soldering tags. Other models for printed panel mounting are planned for production in the near future.

EE 32 757 *for further details*

DIGITAL DATA LINK EQUIPMENT

(Illustrated above right)

Ericsson Telephones Ltd, Beeston, Nottingham

With the advent of centralized computing a requirement has arisen for a convenient means of transmitting data to the computer centre from a variety of separate and widely dispersed points. Although telephone or telex circuits in many cases already exist, these are inadequate for the large volume of traffic involved.

This digital data link equipment employs electronic techniques, by means of which binary data can be transmitted at speeds up to 500 bauds over medium

such as the normal G.P.O. system, or private wires.

The equipment at the transmit end comprises an input device, such as a magnetic or punched tape reader, and a frequency modulated transmitter. An error correcting encoder is also incorporated, to eliminate errors introduced by the sporadic bursts of interference which are an inherent feature of most telephone systems. At the receive end the equipment consists of an amplifier and detector, followed by an error correcting decoder. Both the transmitter and receiver are designed for use with 5-hole punched tape. They can, however, be readily modified to operate with 6-, 7- or 8-hole tape, or from other media if required. The received and decoded signal may be read out either serially, or in parallel form, and may be applied via suitable buffering equipment to tape reperforators, magnetic tape recorders and printers. Indication that the equipment is functioning correctly, and is ready for service can be included at the transmit end, and facilities provided for automatic clear down at the end of a transmission.

Both transmitter and receiver units are fully transistorized, and high grade components are used throughout, consequently the equipment is reliable in service, and economical to run.

The transmitter and receiver are both suitable for mounting on a standard 19in rack, or in an instrument case.

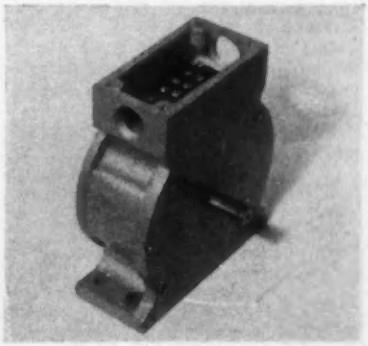
EE 32 758 *for further details*

HIGH-SPEED IMPULSE SWITCH

(Illustrated below)

Lancashire Dynamo Electronic Products Ltd, Rugely, Staffordshire

This new electromechanical switching unit is designed to provide electrical circuit switching from the rotation of a shaft by means of cam-operated heavy duty switches.



The housing is splash-proof and is of cast light alloy construction. Mounting is either by foot or by flange, both being integral parts of the housing. The switch is driven by a ¼in diameter input shaft which is supported in a sealed bearing at each end of the assembly. Two sets of heavy duty leaf spring contacts are included and the operation is determined by the form of the cam.

The rotary switch is primarily intended for use with the Series F43 high-speed electromagnetic counter unit, but with an alternative cam-form the unit is suited to limit switching on rotary valve actuators and similar applications.

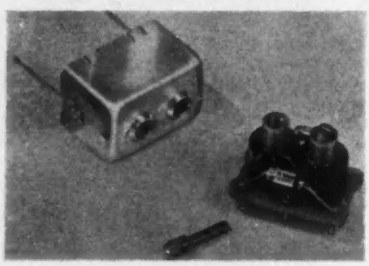
EE 32 759 *for further details*

MOTORIZED TELEVISION TURRET

(Illustrated below)

The Plessey Co. Ltd, Vicarage Lane, Ilford, Essex

A new motor-driven turret tuner designed to cover all television channels and f.m. channels, has been introduced by The Plessey Company. This new unit, type PL 14M, will facilitate the use



of remote control and push-button tuning techniques in domestic receivers. No mechanical loading falls on the push-buttons which are used only to switch electrical circuits.

Using the latest frame grid valves, the r.f./oscillator unit features high gain, low noise and low drift characteristics.

New contact design in the turret affords accurate resetting with minimum frequency drift. For special applications, however, a fine tuner is available as an optional fitment.

The specially developed motor drive unit for the turret tuner uses a mains voltage induction motor to eliminate interference. Accurate resetting by self-indexing the turret, and automatic disconnexion to prevent overrun when the motor is switched off, are provided by a special clutch unit.

This motorized turret tuner can be mounted anywhere in the receiver as its position is not dictated by the need for external controls.

Operating time of the tuner for 360° rotation is 7sec.

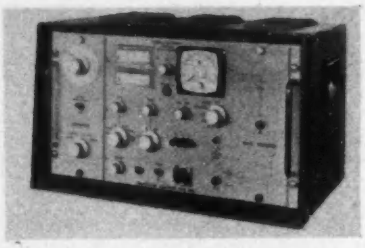
EE 32 760 *for further details*

TRANSISTOR ANALYSER

(Illustrated above right)

Microcell Electronics Ltd, Blackwater, Camberley, Surrey

This instrument is designed to measure to a high degree of accuracy the para-



meters of pnp and npn transistors, and incorporates several features which will commend it to the circuit designer who requires more accurate information on individual transistors than the manufacturers normally supply. It is particularly suitable for the selection of matched sets of transistors.

Parameters which can be measured are amplification factor (β), cut-off frequency (f_{co}'), collector leakage current (I_{co}') and collector turnover voltage (V_{to}) and I_{co}' of diodes.

Features of the instrument are the use of a differential input, wideband valve-voltmeter as a β indicator and a wide-band oscillator as a signal source. The valve voltmeter form of indicator effectively nullifies errors due to spurious voltages developed across the ratio networks. The response of this valve-voltmeter is within ±1·5dB from 1kc/s to 10Mc/s. The oscillator which is a Wein bridge type covers the range 1kc/s to 10Mc/s and is amplitude stabilized to within ±1·5dB.

Collector supplies are fully stabilized as is the supply for the oscillator and valve-voltmeter.

Collector voltage and collector current are monitored on edge-type meters stacked one above the other so that both may be watched simultaneously and all the meters are fully protected against overload. Base current may be measured by plugging in an external meter.

Provision is made for external adaptors to be used in order to measure transistor h parameters, etc.

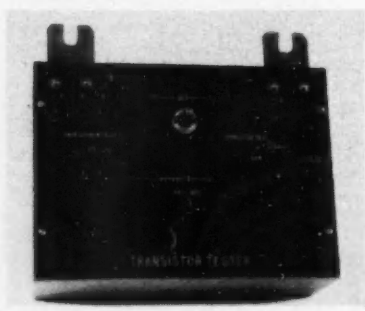
EE 32 761 *for further details*

TRANSISTOR TESTER

(Illustrated below)

Grundy & Partners Ltd, 3 The Causeway, Teddington, Middlesex

The tester is designed for use in conjunction with all multi-range meters of 1mA basic movement or better, prefer-



ably with built-in overload protection. The mounting terminals enable the unit to be mounted directly on to a Universal Avo-Meter.

Transistor measurements include collector-emitter, and collector-base leakage current (I_{co}') and (I_{co}) respectively, at a potential of 4·5V.

Diodes are tested in the forward direction by passing a current of up to 10mA depending on the forward resistance. The reverse current is checked at a potential of 9V.

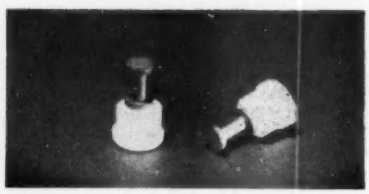
A useful measurement of current gain (β) can be made of transistors up to 800mW dissipation and a reasonable indication is given for higher powers.

Five switched base input currents are available of 5, 10, 50, 100 and 500μA. The collector voltage being fixed at 4·5V.

It is possible, using the two sets of terminals provided, to match or compare two similar transistors or diodes in a minimum of time under exactly the same conditions.

Provision is made for testing the internal battery under load, thus eliminating the possibility of error due to battery failure.

EE 32 762 *for further details*



MIDGET STAND-OFF TERMINAL

(Illustrated above)

Sealectro Corporation, Hersham Factory Estate, Lyon Road, Walton-on-Thames, Surrey

This midget stand-off terminal has a turret stud with Teflon body for 'press-fit' installation technique. Overall length of the new unit is 0·296in, while the soldering lug measures 0·156in long. The through-chassis Teflon body is 0·148in diameter, with a 0·172in diameter shoulder for chassis support. The solder lug is made of brass. The new terminal is available in all standard colours for circuit coding.

EE 32 763 *for further details*

ROTARY STEPPING RELAY

(Illustrated on page 255)

Thorn Electrical Industries Ltd, Thorn House, Upper St. Martins Lane, London, W.C.2

This 'three-in-one' rotary stepping relay is a combination of (1) a standard relay with a knife-edge armature pivot operating contact springs, and a ratchet and pawl driven stepping mechanism, (2) a ratchet driven rotary switch consisting of four banks of 12 points each with sliding bifurcated spring wipers, and (3) a ratchet driven stepping relay with two cams which open and close double contact type springs in accordance with the cam pattern.

The rotary switch terminals are arranged in a circular pattern with four

Points to note when choosing a High Power Oscillator

HIGH POWER OSCILLATOR/AMPLIFIER TYPE 254

VERSATILITY **Is the instrument capable, as it stands, of performing a wide variety of duties?**

The Airmec Oscillator/Amplifier Type 254 consists of a 150-watt amplifier, which may be driven from an internal oscillator operating over the range 30 c/s to 30 kc/s, or from an external source. It is fully equipped with metering and protective circuits, and may be applied as a power source for "odd-frequency" equipment, vibrators, and small servomotors, for double-voltage, double-frequency testing of transformers, and for use as a high power audio amplifier.

LOAD IMPEDANCE **Can a variety of loads be matched efficiently?**

Reasonably good matching is essential to reduce distortion and to enable full power output to be obtained. The output transformer of the Airmec Oscillator/Amplifier Type 254 has a number of secondary windings, which may be switched into series/parallel combination to match loads between 16.7 and 4,270 ohms.

POWER OUTPUT **Is the available power output sufficient?**

An amplifier may be designed to provide almost any degree of power, but only at great expense and by using special techniques. The Airmec Oscillator/Amplifier Type 254 provides a useful output with conventional circuitry, the maximum continuous sine-wave output being 150 watts from 50 c/s to 5 kc/s, which is maintained at 100 watts at 30c/s and 10 kc/s and is still 50 watts at 30 kc/s.

HUM AND NOISE **Is the level of spurious signals acceptable?**

Excessive hum and noise can be a severe disadvantage in any application involving ancillary equipment or comparative measurements. The total hum and noise produced by the Airmec Oscillator/Amplifier Type 254 does not exceed 40 mV at any output impedance.

PRICE AND DELIVERY **Are both the price and delivery reasonable?**

The price of the Airmec Oscillator/Amplifier Type 254 is only £200 and delivery is immediate.

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EE 32 119 *for further details*

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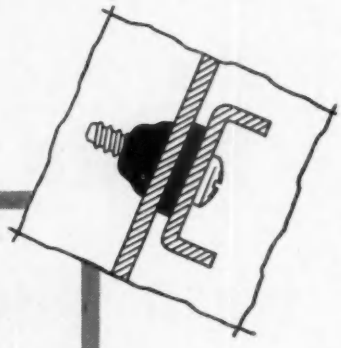

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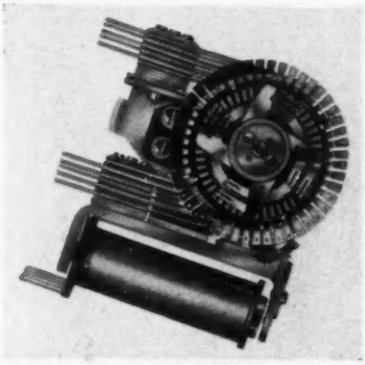
banks of twelve points each. Each bank comprises a quadrant of the circle and contains a common buss which is connected to the 12 isolated points in sequence by means of a sliding wiper as the switch is operated. The four bifurcated sliding wipers are made of phosphor bronze and the wiper contact assemblies are insulated electrically from each other. The contacts of the rotary switch bank are capable of carrying 0·5A on a steady state basis and of interrupting 0·1A at 50V d.c. with a resistive load.

The ratchet driven stepping relay has two circular cams sharing space on a common shaft which actuates the rotary switch wipers. Each of the two cams actuates up to five contact springs in accordance with the predetermined cam pattern.



In addition there are two contact sets with a maximum of four springs each which open and close with every step of the rotary stepping relay switch. All the contact springs are the long leaf spring type with supports to ensure long life and trouble-free operation. The twin noble metal contact points are capable of handling 1·0A steady state and of interrupting 0·5A at 50V d.c. with a resistive load.

Coil voltages are 12, 24, 48 and 110V d.c. Two standard coils are available: (1) a high speed low inductance coil capable of stepping the switch at a rate of 40 steps per second (power requirement 4W) and (2) a more sensitive low speed coil capable of stepping the switch at a rate of 20 steps per second (power requirement 2W).

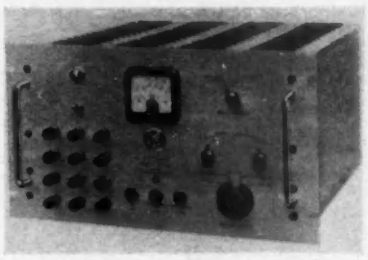
EE 32 764 *for further details*

STABILIZED POWER SUPPLY

(Illustrated above right)

W. G. Pye & Co. Ltd., P.O. Box 60, Cambridge

This general purpose laboratory power supply features four main outputs; a stabilized h.t. supply, continuously variable from −10 to +500V, with a maximum output of 250mA, a 250V stabilized bias supply, and two centre-tapped 6·3V 5A heater outputs. All these supplies are 'floating', so that any terminal or each may be earthed, or for a.c. voltages they may be connected in series or parallel. Voltage control of the



500V output is achieved with a combination of a four-position switch and a potentiometer; the former control selects the output range, each position covering nominally 125V, and the latter gives continuous control within each range, with some 10V overlap at each end. At the lower end of the 0 to 125V range, the output can be swung through zero up to ten volts negative.

A meter is provided with which either voltage or current output from the h.t. supply can be read. The full-scale deflexion of the meter is automatically adjusted either to 250 or to 500V, according to which output range is in use.

When reading current, sensitivities of 250 or of 50mA can be selected. The meter face is scaled for all these ranges. Ripple on the high-voltage supply is less than 3mV, and regulation better than 0·1 per cent output voltage variation for 10 per cent input change. The internal impedance of the supply is below 0·75Ω form d.c. to 50kc/s.

The bias supply is fixed at 250V stabilized, and 30mA may be drawn from it if desired. However, a potentiometer connected across the supply enables a variable bias potential to be obtained.

Other features of the design include full overload and short-circuit protection.

EE 32 765 *for further details*

NUCLEAR 'HOT SPOT' MONITOR

(Illustrated below)

Avo Ltd, Avocet House, 92-96 Vauxhall Bridge Road, London, S.W.1

Designed for the measurement of 'hot spots' of beta gamma radiation over the range 0·05 to 100r/h, this instrument is

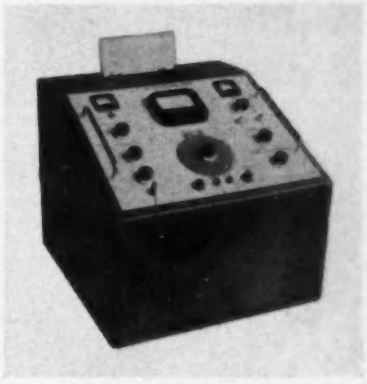
intended for determination of hot spots of local radioactive material which may have been deposited during processing.

The ionization chamber can be mounted on any combination of three interlocking extension rods and a flexible connector allowing the ionization chamber to be at a distance of up to 13ft from the operator.

The ionization chamber, which has a volume of 160cm³, is made of an aluminium cage, supporting a 'Melinex' foil 0·00025in thick.

A small strontium 90 source situated in the chamber together with two switches on the indicator unit, enable the operator to carry out operational checks even when the chamber is in an intense field.

EE 32 766 *for further details*



SPECTRUM ANALYSER

(Illustrated above)

Fenlow Electronics Ltd, Springfield Lane, Weybridge, Surrey

This instrument has been designed to analyse the recorded waveforms of vibrations, strains, etc., encountered in engineering. The frequency range of the instrument is from 0·3c/s to 1050c/s. It is transportabe, self-contained, and operates from 200 to 240V 50c/s mains. The prime function of the spectrum analyser is to detect and measure hidden periodicities in recordings.

The instrument has a built-in meter displaying the power of the random waveform in the pass-band to which the instrument is set. Facilities are provided to take out the signal after the filter for recording purposes if required.

Five filter widths are provided giving bandwidths between 0·06c/s and 37·5c/s. The smoothing times available to suit the bandwidth being used are from 1·5 to 150sec.

The instrument contains several novel features and will provide a useful and accurate analysis of the input data. It is a constant bandwidth rather than a constant Q device using the heterodyne system with low-pass output filters and two quadrature channels to prevent ambiguities due to phase synchronization for almost periodic inputs. Accurate square law thermocouples are used to measure the power, these being followed

by the smoothing unit with controllable smoothing times.

The controls and output meter are on the sloping panel together with the input and output terminals. Monitor points are available by removal of a cover on the top of the instrument; since the spectrum analyser contains seven operational amplifiers this means that it is possible to use these for other purposes when the instrument is not being used for analysis, they may for example be used to simulate the equations of a mechanical system.

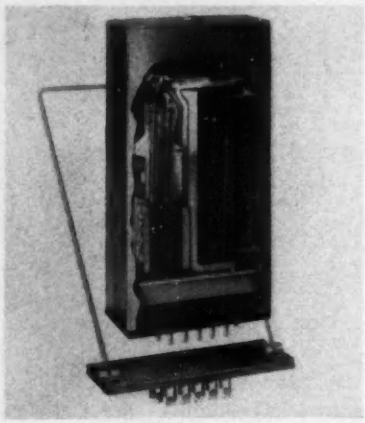
EE 32 767 *for further details*

PLUG-IN RELAY

(Illustrated below)

The Keyswitch Company, 2 Irongate Wharf Road, Praed Street, London W.2

The P-32 plug-in 3 000 type relay is available with any P.O. 3 000 type relay to standard G.P.O. specifications,



i.e., from 2 to 18 springs (1 make to 6 changeovers).

The contacts may be twin silver (300mA); twin palladium or twin platinum (1A); heavy duty fine silver (2A); silver-cadmium-oxide or silver nickel (8A).

Plug and socket rating is 250V a.c. or d.c. Positive contact is definite between male and female pins. A clip retains the relay positively in any position.

The relay is supplied complete with transparent or metal cover, and socket.

EE 32 768 *for further details*

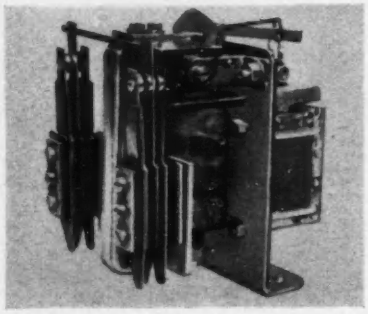
LATCHING RELAYS

(Illustrated above right)

Electrical Remote Control Co. Ltd, Elremco Works, Bush Fair, Harlow, Essex

The latching relay type UNIV/LA, which can carry up to eight contact sets, normally open, normally closed, changeover, or mixed, is held by a simple latching mechanism in the energized position after a short pulse is applied to the coil. When the lever attached to the relay is pressed, the relay contacts are released to the de-energized position, remaining there until a further pulse is applied to the coil.

The latching relay UNIV/LA/S (illustrated) is similar to the hand reset version above, but can be both latched and unlatched by electrical impulse. It is fitted on a substantial plate serving also as a mounting bracket. Attached to the plate is a small solenoid which, when energized, releases the latching device.



The range of coils available covers requirements up to 440V a.c. or 230V d.c. The contacts are rated at 6A, 230V a.c. or 2A, 440V a.c. or 1A, 240V d.c.

EE 32 769 *for further details*

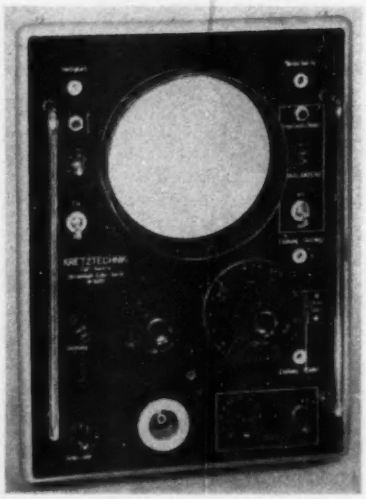
ULTRASONIC THICKNESS GAUGE

(Illustrated below)

Distributed by: Aveley Electric Ltd, Ayron Road, Aveley Industrial Estate, South Ockendon, Essex

The Kretz ultrasonic thickness testing instrument Type 6000 incorporates a high stability wideband amplifier having a frequency range of 3Mc/s to 20Mc/s, and has been specially designed to include facilities for the accurate measurement of dilation or contraction, and a special triggering circuit to give warning when a predetermined limit of measurement has been reached.

Thickness measurements are accurately obtained by spanning several pulses with a movable pedestal whose leading edge can be moved to divide the first cycle of each ringing pulse. The higher the number of echo-pulses used for measurement, the greater the discrimination obtained. The vertical deflexion response of the trace is better than 0·05μsec so that an echo-time discrimination of 0·0125μsec is obtained.



The unit has an effective depth range from 1cm to 70cm for flaw detection, and for thickness gauging a maximum range of 20mm dependent on frequency and attenuation of the material under test. The power consumption is 180VA. A low voltage socket is provided for certain types of work where stringent electrical safety precautions are essential. The use of this socket automatically makes the high voltage connexion inoperative.

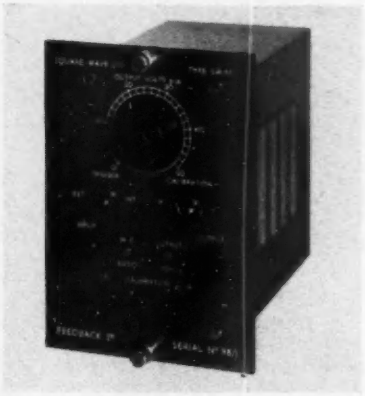
EE 32 770 *for further details*

SQUARE WAVE UNIT

(Illustrated below)

Feedback Ltd, Crowborough, Sussex

The square-wave unit type SW98 manufactured by Feedback Ltd, an associate company of Servomex Controls Ltd, provides a square-wave driving signal for repetitive analogues. A square-wave at mains frequency is provided, and the unit also generates square-waves from externally applied sine-waves over the frequency range 50c/s to 10c/s. The rise-time is about 2μsec for any operating frequency and a mark-to-space ratio trimmer is provided to enable an exact 1:1 ratio to be obtained.



The minimum external signal for satisfactory operation is 2V peak, and the output is continuously adjustable from 0 to 50V peak-to-peak independently of the input amplitude.

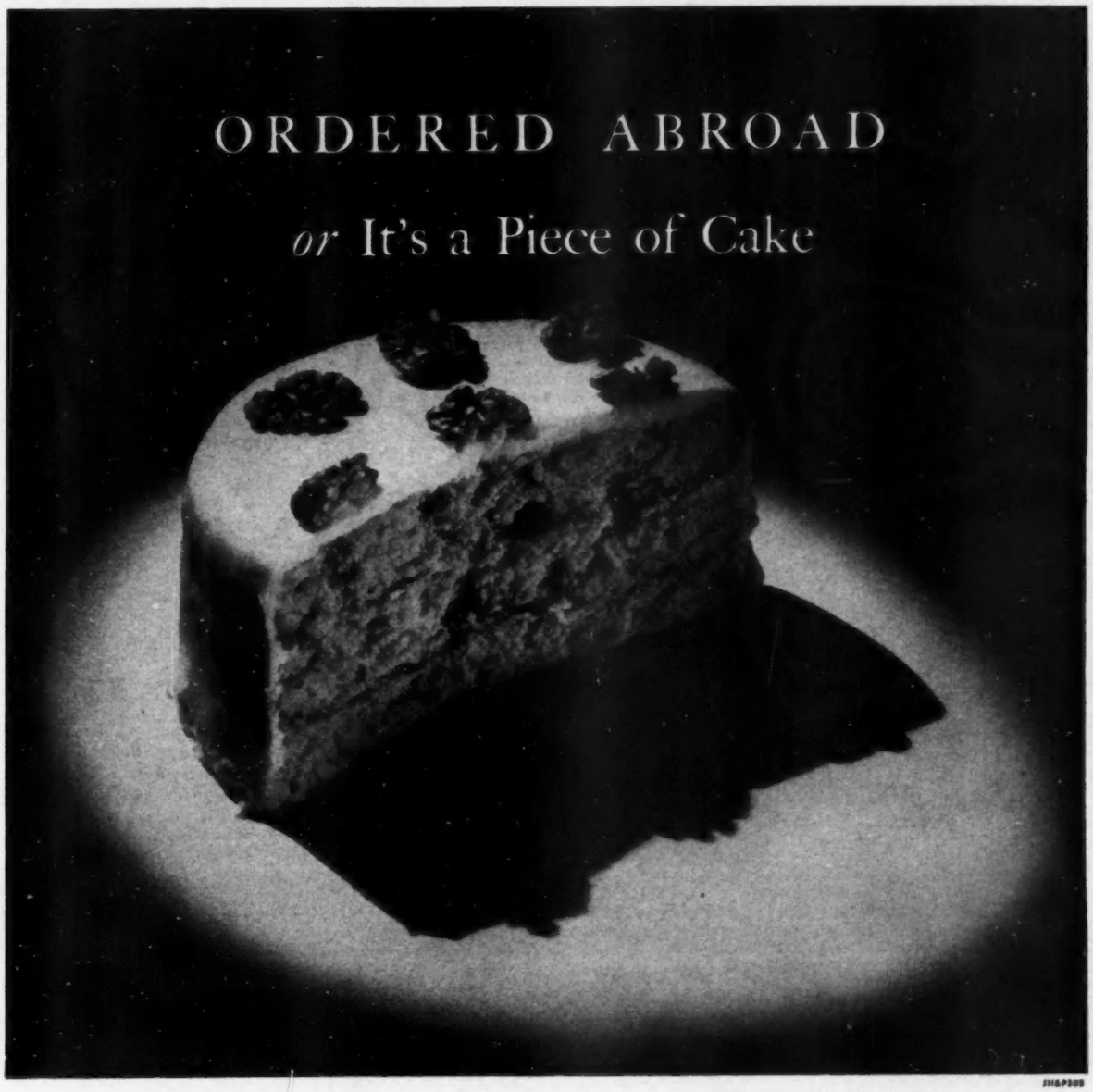
A tuned circuit has been incorporated to generate a calibration oscillation for time measurement on an oscilloscope trace for use with repetitive analogues. The calibration frequency is 2·5kc/s, and the oscillation train may be switched to occur during either the positive or negative half of the square-wave.

EE 32 771 *for further details*

INDUSTRIAL MEASUREMENT EQUIPMENT

Ekco Electronics Ltd, Southend-on-Sea, Essex

Three new Ekco instruments are available with specific application to industrial processes. The moisture gauge type N680 is designed primarily for use on paper-making machines and provides accurate indication of moisture present



A Gripping Contemporary Drama

Sell or sink! At a time when exports mean so much to the nation, we reflect with some pride on our own achievement. ***Almost half our production goes overseas.*** By any standard of judgement, that's a pretty hefty slice of the cake.

But, we feel bound to add, we *ought* to be able to export such a high proportion. We have our equipments to thank for this. With a range as good as ours, the normally difficult business of exporting becomes, quite frankly, *a piece of cake.*

More seriously, BCC design, engineer, instal and service complete communications systems. Our Advisory Service would be glad to have the opportunity of helping to solve *your* problems, in the UK or anywhere else.

BRITISH COMMUNICATIONS CORPORATION LIMITED

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And at Wembley

BCC

EE 32 121 for farther details

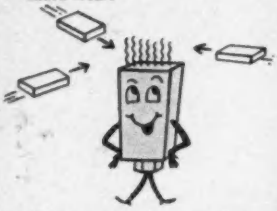
NEW Honeywell Proximity Switch

detects ferrous materials

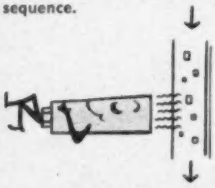
never wears out!

detection without contact!

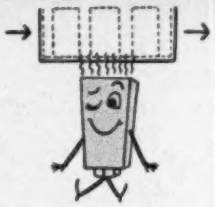
It detects rough or abrasive parts—no physical contact to cause wear.



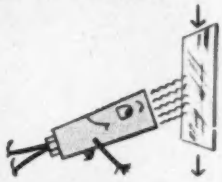
Accepts actuating motion from any direction, in any sequence.



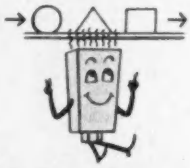
Detects small parts in chute without detaining flow.



'Sees' through stainless, brass, cardboard containers.



Detects delicate or polished surfaces without marring finish.



Detects or counts large, irregular shaped objects.

an environment-proof sensor

Can be submerged, washed down with water and steam and even covered with cutting compounds.

Is completely sealed, has no moving parts, is unaffected by dust, grit, abrasives.

Its stainless steel sensing face protects against damage.

The sensor is provided with 6 feet of wire for connecting to the amplifier. This length can be cut or extended with ordinary electrical wire. No shielding is required up to a length of at least 150 feet.

WRITE OR SEND THE COUPON TODAY to
Honeywell Controls Limited, Greenford, Middlesex. Waxlow 2333.

I should like brochure MIC 6 on your new Proximity Switch.

NAME .....

COMPANY .....

POSITION .....

ADDRESS .....

..... EE

Sales Offices in the principal towns and cities in the United Kingdom and throughout the world.

Honeywell

Fast in Micro Switches

in paper within the range 2 to 75 per cent of moisture content. Alternative models are available giving limited ranges such as 2 to 15 per cent and 60 to 75 per cent. The instrument can be used as a moisture controller at the dry end of the machine and can also be used in conjunction with an Ekco substance gauge at the wet end. The latter arrangement makes it possible to measure the dry substance weight at a stage in manufacture previously impossible.

The storage unit type N682, principally designed for coating applications, retains a gauge reading for a pre-set time related to the production process, means being provided to synchronize the delay with machine speed. This enables a base material reading to be compared with a reading from a second gauge measuring the coated material. With the delay afforded by the storage unit the 'coated' and 'uncoated' readings for the same area of material can be compared after the drying or curing process. The difference signals are then applied to an automatic control unit operating screw-down motors on the dip roller or doctor blade. Direct readings of the coating weights applied can also be given on a meter or chart recorder.

Continuous and accurate measurement of metals produced in strip form up to 0·5in thick is provided by the secondary X-ray gauge type N658 in which X-rays are generated as Bremstrahlung from a strontium 90 source. Completely automatic control facilities are provided by the in-built auto control unit type N604.

EE 32 772 *for further deatils*

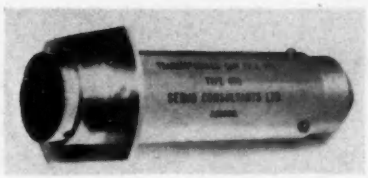
'ELECTRONIC MICROSWITCHES'

(Illustrated above right)

Servo Consultants Ltd, 10 Bouverie Place, London, W.2

This unit has been designed to fulfil a need for a robust and contactless device for synchronizing the operation of automatic machinery. The unit is essentially intended to replace a pair of electrical contacts operated mechanically by a cam on a machine. The cam pick-off contains no moving parts and therefore its life expectancy is extremely long. All electronic components used have liberal ratings, and the whole device is constructed in such a way as to withstand the extreme conditions of vibration encountered in many industrial applications.

The unit can be actuated by a moving cam, rack or similar device, the only essential being that this device should be made of magnetic material. The normal gap between the front end of the unit and the cam can vary between 0 and 0·030in for the 'on' conditions, and should be more than 0·25in for the 'off' conditions. The 'on' and 'off' conditions are purely arbitrary and the device will stay indefinitely in either of the two states. its range of response extends therefore from d.c. operation to approximately 1 000 rev/min. The accuracy of resolution is ±0·020in, giving an angular



accuracy of approximately 25min of arc when using a 6in diameter cam.

EE 32 773 *for further details*

MILLIMETRE KLYSTRONS

Elliott Brothers (London) Ltd, 34 Portland Place, London, W.1

Four new klystron oscillators for the 4mm, 6mm and 12mm bands have been developed by Elliot Brothers.

Water-cooled and built on the floating drift-tube principle, these klystrons produce output signals exceptionally free from thermal drift and hysteresis. The glass used in the construction of the envelopes has a high-temperature softening-point and is sealed to molybdenum. This makes it possible to bake the valves at 700°C during the process of manufacture and results in an extremely high vacuum, good low-noise characteristics and improved cathode-durability. Average life expectancy is at least 500 hours.

The 4KF1, which embodies many of the components used in the 15 watt Q-band klystron 8FK1, is capable of a power output greater than 100mW at a fixed frequency of about 75kMc/s.

Two klystrons are now in production for the 6mm band: the 6FK1, a fixed-frequency oscillator which delivers a power output of about 2W at 50kMc/s; and the 6TFK2, a tunable version of the 6FK1.

The 12TFK2, a new 12mm oscillator, is a tunable version of the 10 watt, fixed-frequency oscillator 12FK1. It gives a power output of 8W minimum, over a 1 000Mc/s range, centred in the band 21 to 25kMc/s.

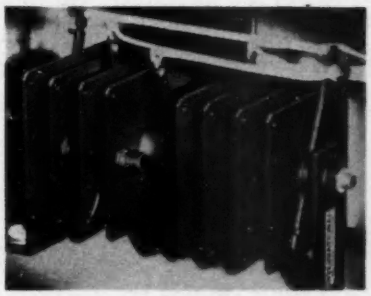
EE 32 774 *for further details*

SILICON RECTIFIERS

(Illustrated below)

International Rectifier Co. (Great Britain) Ltd, Hurst Green, Oxted, Surrey

A new range of medium power silicon rectifier stacks is now being offered by International Rectifier Co. (G.B.) Ltd. The range of stacks is designed to cover the most commonly met outputs for



power supplies in such equipment as power amplifiers, radio transmission gear, computer power packs, etc.

Stacks are available in single-phase half wave, single-phase bridge and three-phase bridge configurations and stacks have efficiencies of up to 98 per cent, thus reducing heating problems. Their high output to size ratio makes them easily interchangeable in existing equipments, and reduces space requirements in new designs to a minimum. All assemblies are robustly constructed with 'plate lock' fins and terminals, open ended mounting slots and colour coded terminals.

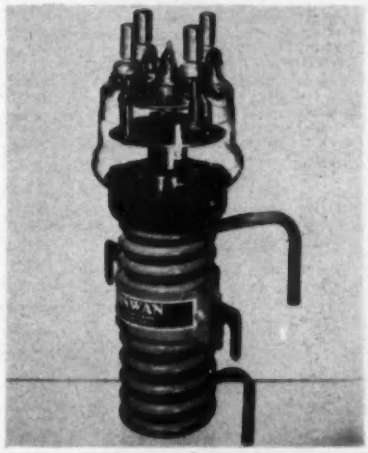
EE 32 775 *for further details*

R.F. POWER VALVES

(Illustrated below)

Associated Electrical Industries Ltd, 155 Charing Cross Road, London, W.C.2

A new method of cooling that is claimed to be more efficient and to make



the valve cheaper to install and easier to maintain is embodied in three new Ediswan water cooled r.f. power valves. Instead of the conventional water jacket, a spiral copper water tube is attached directly to the anode. The valves are type 15P12 with maximum anode dissipation of 0·6kW and maximum r.f. power output of 2·5kW, and types 16P12 and 16P13 both with maximum anode dissipation of 3kW and maximum r.f. power output of 7·5kW.

Because there are no seals, water leakage risk is reduced. The complete valve in each case is more compact than comparable conventionally cooled types. Water requirements are low at approximately 1 litre for 3kW anode dissipation. An Ediswan patented over-dissipation protection device is incorporated.

Suffixes 12 and 13 denote the type of water coupling provided, e.g. the 16P12 is connected by flexible tubing, the 16P13 by unions.

The 15P12 has a grid constructed of a new non-emitting material which permits much higher grid dissipation.

EE 32 776 *for further details*

Meetings this Month

THE BRITISH INSTITUTION OF RADIO ENGINEERS

London Meetings

Date: 6 April. Time: 5.30 p.m.
Held at: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Discussion: Transistorized Television Receivers.

Date: 12 April. Time: 5.30 p.m.
Held at: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: Vibration Analysis and Testing.
By: D. E. Mullinger.

Date: 19 April. Time: 6 p.m.
Held at: University College Medical School, University Street, Gower Street, London, W.C.1.
Lecture: Instrumentation for Obstetrics.
By: Dr. C. N. Smyth.

Date: 26 April. Time: 6 p.m.
Held at: London School of Hygeine and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: Electronic Counting Ttechniques.

West Midlands Section

Date: 19 April. Time: 6.15 p.m.
Held at: Electrical Engineering Dept., The University of Birmingham.
A Programme of Technical Films.

South Western Section

Date: 19 April. Time: 7 p.m.
Held at: School of Management Studies, Unity Street, Bristol.
Lecture: Colour Television.
By: G. N. Patchett.

South Midlands Section

Date: 21 April. Time: 7 p.m.
Held at: North Gloucestershire Technical College.
Lecture: The Mesa Transistor and its H.F. Applications.
By: D. H. Mehrtens.

Southern Section

Date: 19 April. Time: 7 p.m.
Held at: Southampton University (Lanchester Building).
Lecture: The Development of an Ammonia Maser Oscillator as a Frequency Standard.
By: A. Mitchell.

BRITISH SOUND RECORDING ASSOCIATION

Date: 21 April. Time: 7.15 p.m.
Held at: Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.
Lecture: Recording Vision Signals on Tape.
By: P. E. Axon.

THE INSTITUTE OF NAVIGATION

Date: 21 April. Time: 5.15 p.m.
Held at: The Royal Geographical Society, 1 Kensington Gore, London, S.W.7.
Lecture: Marine Radar Presentation.
By: Mr. S. R. Parsons and Captain F. J. Wylie.

THE INSTITUTION OF ELECTRICAL ENGINEERS

All meetings will be held at Savoy Place, commencing at 5.30 p.m., unless otherwise stated.

Medical Electronics Discussion Group

Date: 7 April.
Discussion: The Conversion of Biological Data into Electrical Signals.

Electronics and Communications Section

Date: 10 April.
Lecture: Applications of Electrical Phenomena at Liquid Helium Temperatures.
By: R. E. Hayes.

Date: 26 April.
Lecture: Data Transmission.
By: R. H. Franklin and J. Rhodes.

Supply Section

Date: 12 April.
Lecture: The Calculation of the Magnetic Field of Rotating Machines—Part 2—The Field of Turbo-Generator End-Windings.
By: D. S. Ashworth and P. Hammond.

Lecture: The Magnetic Field of the End-Windings of Turbo-Alternators.
By: P. J. Lawrenson.

Date: 19 April.
Lecture: Progress in Oil-Filled Cables and their Accessories.
By: A. N. Arman, F. J. Miranda and G. R. Bishop.

Utilization Section

Date: 20 April. Time: 6 p.m.
Lecture: Diesel Railway Locomotives.
By: A. D. Swanston and B. W. Towell.
Lecture: Aluminium in Electrical Engineering.
By: P. J. H. Rata.
Lecture: Automatic Programming for Hot Reversing Mills.
By: T. E. S. Rickard.

Measurement and Control Section

Date: 25 April.
Lecture: Simulation of Intelligence.
By: Professor D. M. Mackay.

Ordinary Meeting

Date: 27 April.
Lecture: The Fifty-Second Kelvin Lecture on Medical Electronics.
By: Professor R. F. Woolmer.

THE INSTITUTION OF ELECTRONICS

Date: 21 April. Time: 7 p.m.
Held at: The Large Lecture Theatre, The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: Modern Transistors and Their Applications.
By: T. D. Towers.
Date: 21 April. Time: 7 p.m.
Held at: The Lecture Theatre, The Byng Kenrick Suite, The New College of Technology, Gosta Green, Birmingham 4.
Lecture: Iong-Distance Communication by Circular Wave Guide.
By: F. J. D. Taylor.
Date: 28 April. Time: 7 p.m.
Held at: The Reynolds Hall of the Manchester College of Science and Technology, Sackville Street, Manchester 1.
Lecture Demonstration: Techniques for Digital Data Links.
By: F. G. Heath.

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Date: 19 April. Time: 5 p.m.
Held at: Conference Room, Waterloo Bridge House, S.E.1.
Lecture: Cleaning Telecommunications Equipment.
By: D. C. Smith.

THE PLASTICS INSTITUTE

Date: 11 April: Time: 6.30 p.m.
Held at: Wellcome Building, Euston Road, London, N.W.1.
Lecture: Some Recent Developments in Reinforced Plastics.
By: T. P. R. Lant.

THE SOCIETY OF INSTRUMENT TECHNOLOGY

Date: 19 April. Time: 7 p.m.
Held at: Manson House, 26 Portland Place, London, W.1.
Lecture: Electronic Telephone Exchanges.
By: T. H. Flowers.
Date: 25 April. Time 7 p.m.
Held at: Manson House, 26 Portland Place, London, W.1.
Lecture: Instrumentation in the Iron and Steel Industry.
By: A. H. Pople.

THE TELEVISION SOCIETY

Date: 14 April. Time: 7 p.m.
Held at: Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.
Lecture: Transparent Phosphor Screens.
By: D. E. N. King.

PUBLICATIONS RECEIVED

BBC HANDBOOK 1961 is an up-to-date reference on the BBC and its activities. It provides background information about the world-wide service given by the BBC with details of the latest developments in television and sound broadcasting. This book is available from the British Broadcasting Corporation, Broadcasting House, London, W.1, price 6s.

THE STRUCTURE AND FUTURE PROSPECTS OF THE ELECTRONIC-BASED INDUSTRIES IN THE UNITED KINGDOM by C. C. Gee is a survey which represents the first attempt to give statistical identity to the electronics industry as it at present exists and to indicate possible trends of development during the next five and ten years. The survey is published by Heywood and Co. Ltd, Drury House, Russell Street, Drury Lane, W.C.2, price 5s.

ABRIDGED VALVE DATA is a reference brochure, which is issued annually, giving abridged data for all English Electric Valve Company valves up to the time of going to press. Detailed data for any type of valve will be supplied upon request and copies of all free publications will be sent to anyone placing their name on the mailing list. Further information is available from English Electric Co. Ltd, Chelmsford, Essex.

A DESCRIPTION OF THE FERRANTI PEGASUS 2 COMPUTER SYSTEM describes the features of the computer, both in its basic form and when used as a data-processing system. Further information on this List DC.44 can be obtained from Ferranti Ltd, London Computer Centre, 68-71 Newman Street, London, W.1.

INTEGRATED DATA PROCESSING AND COMPUTERS is a report on a mission to the United States by a Group of European Experts. This report has been written with the primary object of creating a greater awareness among management of the advantages to be gained from an appropriate degree of integration whenever data processing activities are being reviewed, especially where the introduction of a computer is being considered. Orders and inquiries may be sent to O.E.E.C., Distribution and Sales Service, 33 ru de Franqueville, Paris-16e. The price of this book is 10s.

pH METERS by Electronic Instruments Ltd is a booklet describing this Companies complete range of equipment. Electronic Instruments Ltd of Richmond, Surrey, specialize in the devising, developing and manufacturing of pH Meters for research, development, education, industrial and process control and medicine. Further details are available from I.B.N. Evans, 30 Fleet Street, London, E.C.4.

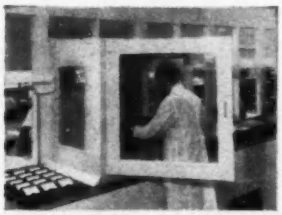
SPIRE SPEED NUTS is the title of a manual now available from Simmonds Aerocessories Ltd, a member of the Firth Cleveland Group. This latest edition includes all the more recent developments in their range of spring steel fastenings. The manual will be of particular interest to designers in the motor, domestic appliance, radio and television industries. Further details are available from Dixon and Partners Ltd, Public Relations, 68 Knightsbridge, London, S.W.1.

THE NUMERITROL CONTROL SYSTEM is a new publication by the Electronic Apparatus Division of Associated Electrical Industries Ltd which describes the continuous numerical control in two- or three-dimensions using ¼in wide magnetic tape as a medium of information to the machine tool. Copies of this publication, No. 4103-1, are available from AEI Publicity Department, Rugby.

CONTRACT ENGINEERING a publication by Negretti and Zambra Ltd of 122 Regent Street, London, W.1, was incorrectly entitled "Contact Engineering" in the March issue.

The best brains in the business... all under one roof!

Pictured below, in descending order, are departments of the new Sifam factory shown at the foot of this page: Electrically Interlocking Hatch from Ultrasonic Cleaning Dept. to Clean Area; Dust-free Air-Conditioned Final Assembly Area; Compression Moulding Shop; Preliminary Assembly Shop and Dial Dept.



The concentration under one roof of exceptionally able design teams, with long experience in many fields of industrial instrumentation, supported by completely up-to-date research and production resources, is an outstanding feature of the new Sifam Factory. Designed solely for the specialist manufacture of electrical measuring instruments and pyrometers to the highest standards, the new plant offers an unrivalled service and a range of instruments unexcelled for craftsmanship and appearance.

Increased capacity enables us to offer the delivery you want—and to maintain it! Write to us now or ask for a Technical Representative to call with details of the latest Sifam developments.

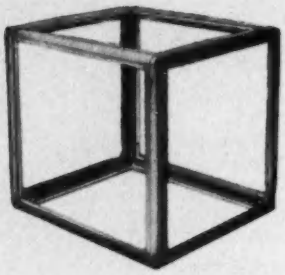
The Wessex range of four instruments is attractively designed in the modern style. The illustration depicts Type 61.

Sifam *Instrumentation*

... skilled craftsmanship and a thirty year old Tradition of Excellence ...

SIFAM ELECTRICAL INSTRUMENT CO. LTD.
Woodland Road, Torquay, Devon
Torquay 63822/3/4 *Telegrams: SIFAM, TORQUAY*

EE 32 123 *for further details*



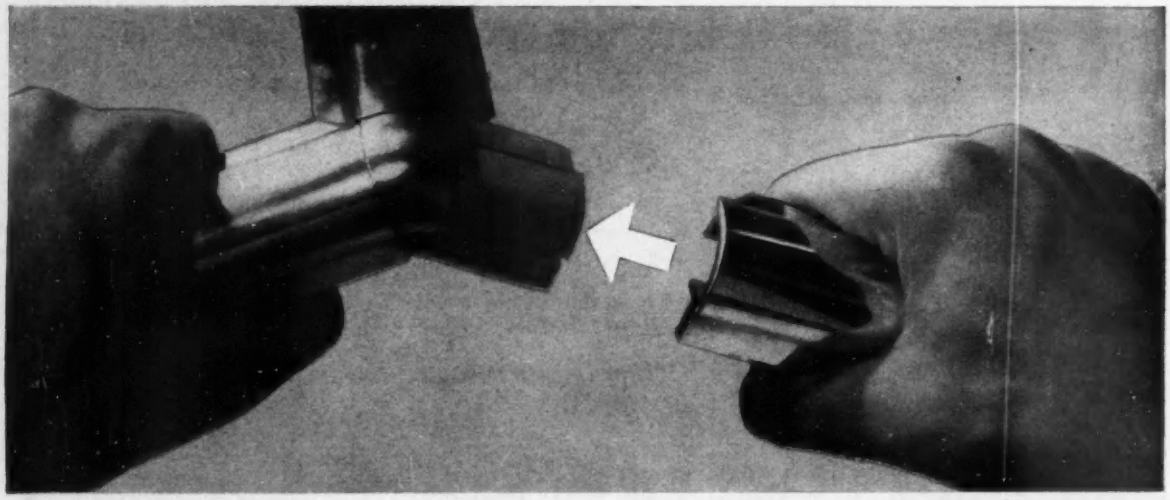
1 **Cut the extrusion to length**
2 **Mitre the ends of the flanges; special IMLOK jigs make this easy**
3 **Slide the extrusion on to the connectors**
4 **Secure the extrusions in place by screwing tight the fixing screws. There you have a strong neat framework, made in minutes**

1 Strangpressprofil zuschneiden
2 Enden der Flanschen gehren: dies wird durch IMLOK-Spezialwerkzeuge erleichtert
3 Profil auf die vorgebohrten Verbindungsstücke aufschieben
4 Schraube in jeden Verbindungsarm einsetzen und festschrauben, sodass das Gestell starr verbunden ist.

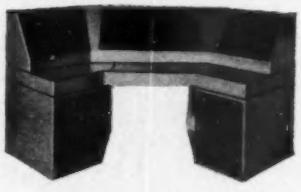
1 **Couper la longueur de métal extrudé désirée**
2 **Biseauter les extrémités des brides; des gabarits IMLOK spéciaux facilitent la tâche**
3 **Faire glisser la pièce extrudée sur des connecteurs préparés d'avance**
4 **Placer une vis dans chaque bras de connexion. Serrer pour obtenir un cadre solide et net**

1 Corte la extravasación del largo
2 Ingletée las puntas de las alas: las plantillas especiales IMLOK facilitan la operación
3 Deslízase la extravasación sobre los conectadores ya taladrados
4 Colóquese la tuerca en cada brazo conectador. Ajústese para formar un armazón fuerte y prolijo.

the *IMLOK* construction system

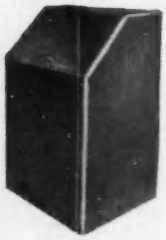


IMLOK — the low cost, unique construction system consists of alloy extrusions and locking corner connectors. It's simplicity itself; you can make precision cases, cabinets—all sorts of structures—to your own design, without any tool costs! Imlok is smart, speedy and strong. You'll find it a boon for research and prototype work, and often the answer to a production problem. Write now for full information.



IMLOK — das billige, einzigartige Bausystem besteht aus Legierungs-Strangpressprofilen und Eckenverbindungen. Es kann nicht einfacher sein! Es ermöglicht Ihnen, Präzisionskabinette, Kästen und andere Bauarten herzustellen, und dies nach Ihren eigenen Wünschen und ohne Werkzeugkosten, IMLOK ist anziehend, schnell und fest. Unentbehrlich für Forschungs- und Prototypearbeiten — und oft auch die Antwort auf andere Produktionsprobleme.
Bitte fordern Sie volle Einzelheiten an!

IMLOK — le système de construction unique à bas prix est constitué de pièces en alliage extrudées et de connecteurs de fixation de coins. C'est la simplicité même! Vous pouvez fabriquer des boîtes et des placards de précision — toutes sortes de structures en fait — d'après vos propres dessins, sans avoir à acheter d'outils. Imlok est élégant, rapide et solide. Vous le trouverez d'une utilité extrême dans vos travaux de laboratoires et pour la construction de vos prototypes; Imlok vous offrira souvent la solution de vos problèmes de production.
Pour plus de renseignements écrivez nous sans tarder.



IMLOK — el costo bajo, el singular sistema de construcción consiste de extravasaciones de aleación y la cerradura de los conectadores de esquinas. Es simplicidad en sí misma: iVd. puede fabricar cajas de precisión, bufetes — todas clases de estructuras — a su propio diseño, sin costo de herramientas! Imlok es elegante, rápido y fuerte. Lo encontrará un don para trabajo de investigación y de prototipo, y frecuentemente la respuesta para problemas de producción Escriba ahora para detalles completos.

Alfred Imhof Ltd., Dept F4, Ashley Works, Cowley Mill Road, Uxbridge, Middx.
Telephone: Uxbridge 37123 Telex: 24177 Telegrams: Imcase, Uxbridge, Telex

IMHOFS AGENTS OVERSEAS

Algeria: E.G.E.E., Paris (19)
Australia: Aladdin Industries (Pty) Ltd. Stanmore NSW
Belgium: Rogelec, Ghent
Canada: Measurement Engineering Ltd., Arnprior
Denmark: Tage Schouboe, Copenhagen N
Finland: Oy Scienta Ab. Helsinki
France: E.G.E.E. Paris (19)
Germany: Sunvic Regler GMBH Solingen—Ohligs
Holland: J. Th. van Reijsen, Delft
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Norway: Birger Christensen, Oslo
Portugal: Projectos e Construcoes Lda, Lisbon
South Africa: Switchcraft (Pty) Limited, Johannesburg
Sweden: Electronlund AB, Malmo 1
Switzerland: Walter Blum, Zurich 2/39
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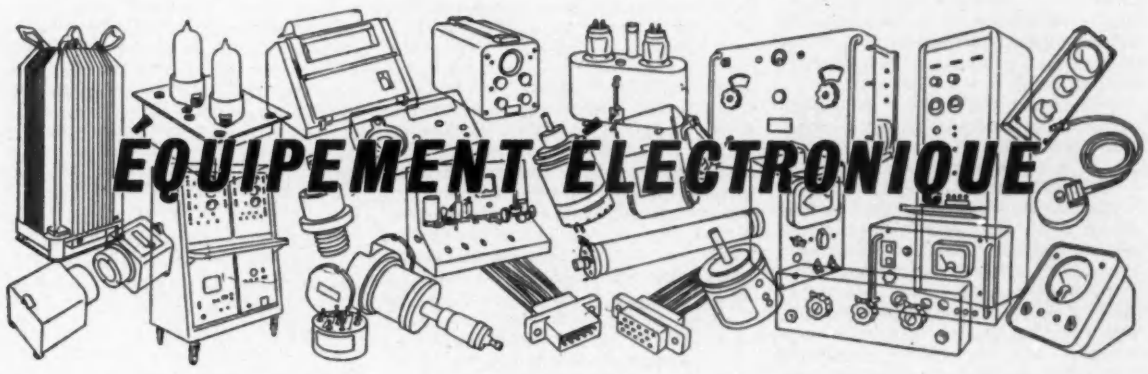
U.S.A.: Bud Radio Inc., Cleveland 3, Ohio
British Guiana: Davsons Caribbean Agencies Ltd., Georgetown



ÉQUIPEMENT ÉLECTRONIQUE

Une description basée sur des renseignements fournis par les fabricants de nouveaux organes, accessoires et instruments d'essai *Traduction des pages 252 à 257*

VOLTMÈTRE NUMÉRIQUE

Solartron Laboratory Instruments Ltd, Cox Lane, Chessington, Surrey

(Illustration à la page 252)

Dans le voltmètre numérique type LM 902.2 les tensions directes de 100 μV à 1.500 kV sont présentées comme indication à 4 chiffres de forme décimale avec discrimination de polarité. L'affichage se fait par projection optique et il est exempt de l'ambiguité propre à certains dispositifs d'indication numérique. Les fonds rouges et noirs représentent des entrées positives et négatives respectivement.

Les mesures de tension se font en trois gammes. L'impédance d'entrée est de 1000 mégohms, sauf dans les deux gammes inférieures, dont les impédances sont de 1 mégohm et 100 mégohms. La précision à long terme est de $\pm 0{,}1\%$ de la lecture maxima dans chaque gamme. Deux gammes de tension supplémentaires de 100 V et 1 kV ont des impédances d'entree de 100 mégohms et une précision de mesure de $\pm 0{,}5\%$.

Le temps de lecture est constant à 280 msec, quelle que soit l'entrée de tension, qui peut être "remontée" jusqu'à 700 V par rapport à la masse.

Une position de contrôle sur le commutateur de gamme permet le réglage du zéro et une vérification de l'étalonnage. La "référence" intérieure Zéner peut être préréglée à sa valeur précise et corrigée si nécessaire en fonction de la cellule étalon incorporée Weston.

Dans les conditions normales d'autofonctionnement, les tensions sont mesurées de façon continue, toute variation provoquant une lecture différente. Pour assurer une souplesse d'application maxima, le modèle LM 902.2 est doté d'une "zone morte" réglable pouvant, dans certaines limites, rendre l'instrument insensible aux changements légers de tension. Ainsi, on peut obtenir des lectures virtuellement exemptes de tout vacillement pour les phénomènes transitoires. Des composantes de bourdonnement de 50 Hz pouvant survenir dans la tension devant être mesurée, peuvent être atténuées ou supprimées en mettant en circuit des constantes de temps courtes ou longues dans le circuit d'entrée.

Lorsqu'on met en circuit le mode de fonctionnement d'échantillonage, une seule lecture de tension est effectuée, soit en actionnant un bouton de panneau soit partélécommande électrique. Cette lecture restera affichée jusqu'a ce que l'échantillon suivant soit pris.

Deux douilles à 50 directions à l'arrière du voltmètre fournissent l'information numérique codée décimale, de même que des signaux de commande de polarité et d'impression pouvant être injectés dans une Tireuse Venner TSA 65 et dans un indicateur supplémentaire.

EE 32 751 *pour plus amples renseignements*

POTENTIOMÈTRE BOBINÉ

Painton & Co. Ltd, Benbridge Drive, Kingsthorpe, Northampton

(Illustration à la page 252)

Le plus récent potentiomètre bobiné, le modèle No. 224, est produit par l'usine de Northampton de la société Painton & Co. Ltd.

Il s'agit d'un instrument de 31,75 mm de long, fonctionnant à 175°C et scellé contre l'humidité, les liquides et les composés de moulage.

FOIRE INTERNATIONALE DE HANOVRE

"Electronic Engineering" occupera le Stand 2, dans la Salle 13, à la Foire Internationale de Hanovre, du 30 avril au 9 mai 1961, et les visiteurs y seront les bienvenus.

Le réglage par tourne-vis à autoverrouillage à 22 tours, présente une excellente stabilité anti-chocs, anti-vibrations et anti-accélération, et l'élément bobiné de précision assure un niveau élevé de sûreté de fonctionnement. La dissipation de puissance est de 1 W à 70°C et 0,5 W à 125°C. Les valeurs de résistance vont jusqu'à 100kΩ.

Trois types de configurations de bornes sont prévus; fils isolés, cosses à souder et broches de circuits imprimés.

EE 32 752 *pour plus amples renseignements*

AMPLIFICATEURS À TRANSISTORS MINIATURE

Amplivox Ltd, Beresford Avenue, Wembley, Middlesex

(Illustration à la page 252)

La société Amplivox produit une série de petits amplificateurs basse-fréquence fabriqués selon les techniques de miniaturisation donnant des proportions de microcircuits. Les densités de composantes vont jusqu'à plusieurs centaines par pouce cube et sont obtenues par l'emploi des méthodes de câblage conventionnelles.

Le grand amplificateur qu'on voit sur la gravure permet l'utilisation d'un microphone magnétique miniature dans un circuit microphonique au carbone afin de garantir une meilleure intelligibilité et un meilleur rapport signal/bruit. Il est livrable en plusieurs modèles différents, dont un modèle sous moulage prévu pour répondre aux conditions ministérielles concernant le climat.

Le type sub-miniature, dont la densité en composantes dépasse trois cents par pouce cube, est un amplificateur à trois transistors monté sur plaquette de circuit imprimé mesurant 12.7 mm sur 5 mm. Le gain qui est stabilisé par réaction, est de 76 dB, et la sortie de puissance est d'environ 1 mW dans 600 ohms.

EE 32 753 *pour plus amples renseignements*

TUBE À ONDES PROGRESSIVES

General Electric Co. Ltd, Magnet House, Kingsway, London, W.C.2

La société M-O Valve Co. Ltd, une filiale de la General Electric Co. Ltd, vient de commencer la production d'une nouvelle réalisation dans sa gamme de tubes à ondes progressives de concentration périodique.

Il s'agit du G.E.C. TWC5, un amplificateur de puissance à tubes à ondes progressives, capable de fournir 15 W dans la bande de 5925 à 6425 MHz.

Le G.E.C. TWC5 a été spécialement étudié pour les systèmes de télécommunications multivoies fonctionnant dans la susdite gamme de fréquences porteuses, quoique la largeur de bande prévue puisse être considérablement agrandie.

Une particularité importante du G.E.C. TWC5 est qu'il peut être facilement remplacé dans un circuit magnétique périodique, ce qui constitue un gros progrès par rapport aux types de tubes comparables. Grâce au contrôle rigoureaux en cours de production des composants mécaniques en métal et en verre, ainsi qu'aux tableaux de pompage méticuleusement établis, le tube est assuré d'une longue durée et d'un degré élevé de sûreté de fonctionnement, répondant donc aux plus strictes exigences des systèmes de communications.

EE 32 754 *pour plus amples renseignements*

CONDENSATEURS VARIABLES À VIDE POUSSÉ

English Electric Valve Co. Ltd, Waterhouse Lane, Chelmsford, Essex

(*Illustration à la page 253*)

La English Electric Co. Ltd, vient d'annoncer la réalisation de condensateurs variables à vide poussé, constituant probablement les premiers condensateurs britanniques de ce genre à être mis sur le marché commercial. La série de ces condensateurs se compose de cinq unités, dont trois avec capacités de 5 à 30, 8 à 50 et 16 à 80 pF, et deux avec capacités de 5,5 à 206 pF. La tension de pointe haute-fréquence est de 15 kV pour les trois premières et de 8 et 10 kV pour les deux autres.

Grâce à l'emploi d'un vide élevé comme diélectrique, l 'espacement des plaques du condensateur se trouve réduit à environ un dixième de l'espacement qui serait nécessaire à un élément diélectrique à air, de caractéristiques comparables, ce qui résulte en un condensateur de dessin extrêmement compact. Quoiqu'un format compact soit déjà en maints cas un gros avantage en soi, particulièrement pour les applications militaires et de bord, les avantages supplémentaires d'une capacité et d'une inductance parasites réduites qu'offre le condensateur à vide poussé, en font un élément des plus utiles pour les réalisateurs de circuits haute fréquence pour les matériels de radiodiffusion, commerciaux et industriels.

La construction s'inspire, en principe, de celle fort connue du condensateur fixe à vide poussé dont les composants capacitifs sont formés de cylindres concentriques se chevauchant. Le condensateur variable emploie, toutefois, un souffet métallique faisant partie de l'enceinte à vide afin de transmettre un mouvement axial à un jeu de cylindres, ce qui permet de régler le chevauchement. Le traitement et l'assemblage du souffet mécanique jouent un rôle primordial dans la fabrication très réussie de ces condensateurs. La loi de capacité linéaire est assurée par la nature de la construction, sauf à la capacité minimum, où les effets pelliculaires causent un légère déviation. Ces condensateurs, dont le plus grand ne mesure que 241 mm × 89 mm, sont prévus pour se conformer aux conditions de la norme RCS11.

EE 32 755 *pour plus amples renseignements*

APPAREIL DE MESURE D'HUMIDITÉ

Kappa Electronics, 159 Hammersmith Road, London, W.6

(*Illustration à la page 253*)

Le contrôleur d'humidité Kappa type AB/55 est destiné à la mesure précise et rapide de la teneur en humidité d'une gamme étendue de matériaux.

C'est un instrument sensible à la fréquence qui mesure en unites arbitraires la constante diélectrique du contenu d'une cellule d'essai détachable, cette constante dépendant des propriétés physiques et de la teneur en humidité du matériau. Tout changement de fréquence produit par une variation dans la teneur en humidité de l'échantillon est décelé avec exactitude par un circuit à changement de fréquence et indiqué par une échelle continue étalonnée en 1000 divisions bien espacées.

La fréquence du circuit d'essai est choisie de manière à ce que les lectures ne soient pas affectées par la conductibilité et un choix de grandeurs de cellule permet d'acquérir la certitude que l'échantillon est effectivement représentatif de l'ensemble.

Pour les matériaux courants, de composition et texture assez constantes, le degré de précision pouvant être escompté se situe entre 0.05 et 0,4 dans la gamme d'humidité de 0 à 20%; entre 0,2 et 0,5 dans celle de 20 à 30%; entre 0,3 et 0,7 dans celle de 30 à 40% et entre 0,5 et 1 dans la gamme précitée de 40%.

EE 32 756 *pour plus amples renseignements*

POTENTIOMÈTRES SUB-MINIATURE

Egen Electric Ltd, Charfleet Industrial Estate, Canvey Island, Essex

(*Illustration à la page 253*)

Etudiée pour l'emploi dans les circuits à transistors, cette nouvelle série de potentiomètres Egen présente de nombreuses caractéristiques d'intérêt dans le domaine de la miniaturisation. De construction robuste, sur corps coulé en coquille n'ayant que 12,7 mm de diamètre, ces commandes montées sur douille ont un axe moulé fort solide de 4,8 mm de diamétre maximum et seront livrables avec des valeurs de résistance normales dans la gamme de 1 kΩ à 30 MΩ de loi logarithmique ou linéaire. Des valeurs inférieures peuvent être fournies sur demande spéciale. Deux modèles seront fabriqués initialement, soit le type 363 non-commutable et le type 365 avec comutateur bipolaire à une direction de 50 V 150 VmA, tous deux avec cosses à souder de type standard. D'autres modèles pour montage sur panneau imprimé seront produits prochainement.

EE 32 757 *pour plus amples renseignements*

APPAREIL DE LIAISON DE DONNÉES NUMÉRIQUES

Ericsson Telephones Ltd, Beeston, Nottingham

(*Illustration à la page 253*)

Depuis l'avènement du calcul centralisé, le besoin s'est fait sentir d'un moyen pratique de transmettre des renseignements au centre de calcul à partir d'une variété de points séparés l'un de l'autre et fortement dispersés. Quoique les réseaux téléphoniques et de téléscripteurs existent déjà en beaucoup de cas, ils ne suffisent pas au volume croissant des transmissions.

Ce matériel de liaison numérique met en oeuvre des techniques numériques, au moyen desquelles des données binaires peuvent être transmises à des vitesses de 500 bauds à travers un réseau normal comme, par exemple, celui des P.T.T. ou des lignes privées.

L'appareil comprend à l'extrémité d'émission un dispositif d'entrée, tel qu'un lecteur de bande perforée ou magnétique, et un émetteur modulé en fréquence. Il est aussi pourvu d'une encodeuse afin d'éliminer les erreurs produites par les brouillages sporadiques, qui sont propres à la plupart des systèmes téléphoniques. A l'extrémité de réception, l'appareil se compose d'un amplificateur et d'un détecteur, suivis d'une encodeuse pour la correction des erreurs. L'émetteur, aussi bien que le récepteur, sont prévus pour l'emploi avec une bande perforée à 5 trous. Ils peuvent, cependant, être facilement modifiés pour fonctionner avec des bandes à 6, 7 ou 8 trous, ou par d'autres moyens encore, si nécessaire. Le signal reçu et décodé peut être lu soit en série soit sous forme parallèle, et il peut être appliqué, à l'aide d'un matériel intermédiare approprié, à des reperforateurs de bande ou à des enregistreurs et imprimeurs de bandes magnétiques. L'extrémité d'emission peut être munie d'un dispositif indiquant si l'appareil fonctionne correctement et s'il est prêt à l'utilisation, de même qu'on peut effectuer le dégagement automatique à la fin d'une transmission.

Le récepteur et l'émetteur sont tous deux entièrement transistorisés et des composants de première qualité sont exclusivement utilisés. Le matériel est, par conséquent, d'un fonctionnement sûr et économique.

Tant le récepteur que l'émetteur peuvent être montés sur bâti normal de 48cm ou dans un coffret à instrument.

EE 32 758 *pour plus amples renseignements*

COMMUTATEUR D'IMPULSIONS À ACTION RAPIDE

Lancashire Dynamo Electronic Products Ltd, Rugely, Staffordshire

(Illustration à la page 253)

Ce nouvel élément de commutation électromécanique a été prévu pour assurer la commutation de circuit électrique par la rotation d'un arbre, au moyen de commutateurs de grande puissance commandés par cames.

Le coffret en alliage léger est protégé contre les corps étrangers. Le montage se fait soit par semelle soit par bride, les deux faisant partie intégrante du coffret. Le commutateur est actionné par un arbre d'entrée de 0.95 cm de diamètre, porté par une chaise de palier à chaque extrémité de l'assemblage. Deux jeux de contacts à ressorts à lames sont inclus et le fonctionnement est déterminé par la forme de la came.

Le commutateur rotatif est principalement destiné à être utilisé avec l'élément de comptage électromagnetique à action rapide de la Série F.43, mais en employant une forme de came différente, on peut le rendre propre à limiter la commutation sur des mécanismes de comande à lampes rotatives et à des applications similaires.

EE 32 759 *pour plus amples renseignements*

BLOC ROTACTEUR DE TÉLÉVISION MOTORISÉ

The Plessey Co. Ltd, Vicarage Lane, Ilford, Essex

(Illustration à la page 254)

Un nouveau bloc rotacteur entraîné par moteur et prévu pour couvrir tous les canaux de télévision et de modulation de fréquence a été présenté par la Plessey Company. Ce nouvel appareil, type PLM14M, facilitera l'emploi des méthodes de télécommande et à bouton-poussoir pour les récepteurs d'intérieur. Aucune charge mécanique ne tombe sur les boutons-poussoirs qui ne sont utilisés que pour commuter les circuits électriques.

Utilisant les plus récentes lampes de grille d'images, l'élément à oscillateurs haute-fréquence offre des caractéristiques de grand gain, de faible niveau de bruit et de dérive réduite.

La nouvelle conception des contacts du bloc rotacteur permet le réenclenchement précis avec le minimum de fréquence de dérive. Pour des applications spéciales, cependant, un rotacteur plus précis peut être fourni sous forme d'accessoire facultatif.

L'ensemble à moteur d'entraînement, spécialement réalisé pour le bloc rotacteur, utilise un moteur d'induction de tension de secteur afin d'éliminer les parasites. Un dispositif spécial d'embrayage permet le réenclement précis du bloc rotacteur par autoguidage et le débranchement automatique afin d'empêcher le sur voltage lorsque le moteur est mis hors circuit.

Ce bloc rotacteur motorisé peut être monté n'importe où dans le récepteur car sa position ne dépend pas du besoin de commandes extérieures. Ajoutons, enfin, qu'il met 7 secondes pour effectuer une rotation de 360°.

EE 32 760 *pour plus amples renseignements*

ANALYSEUR DE TRANSISTORS

Microcell Electronics Ltd, Blackwater, Camberley, Surrey

(Illustration à la page 254)

Cet instrument a été conçu pour mesurer, avec un degré élévé de précision, les paramètres des transistors pnp et npn. Il présente plusieurs avantages qui le rendent fort utile au réalisateur de circuits qui exige des renseignements plus précis sur des transistors individuels que n'en fournissent habituellement les fabricants. Il est particulièrement indiqué pour le choix de jeux accordés de transistors.

Les paramètres pouvant être mesurés sont le facteur d'amplification (β), la fréquence de coupure (f_{co}), le courant de fuite au collecteur (I_{co}), la tension de renversement au collecteur (V_{to}) des transistors (montage d'émetteur mis à la masse), ainsi que la tension de fuite au collecteur des diodes.

L'instrument se caractérise par l'utilisation d'une entrée différentielle, d'un voltmètre électronique à large bande servant d'indicateur du facteur d'amplification et d'un oscillateur à large bande servant de source de signaux. L'indicateur à voltmètre électronique annule efficacement toute erreur due à une fausse tension se produisant dans les réseaux de rapport. La réponse de ce voltmètre électronique est, à ± 1.5 dB près de précision, de 1 kHz à 10 MHz. L'oscillateur, qui est du type à pont de Wien, couvre la gamme de 1 kHz à 10 MHz, et il est à amplitude stabilisée à ± 1.5 dB près.

L'alimentation au collecteur est pleinement stabilise, de même que d'alimentation de l'oscillateur et du voltmètre électronique.

La tension au collecteur et le courant au collecteur sont contrôlés par des appareils de mesure empilés l'un sur l'autre, de manière à ce que la tension et le courant puissent être suivis simultanément, et tous les appareils de mesure sont pleinement protégés contre toute surcharge. Le courant de base peut être mesuré en enfichant un appareil de mesure extérieur.

On peut également utiliser des adaptateurs extérieurs pour mesurer les paramètres "h" de transistors, etc.

EE 32 761 *pour plus amples renseignements*

CONTRÔLEUR DE TRANSISTORS

Grundy & Partners Ltd, 3 The Causeway, Teddington, Middlesex

(Illustration à la page 254)

Cet instrument de contrôle a été prévu pour être utilisé en liaison avec tous les multimètres à mouvement de base de 1 mA ou davantage, de préférence avec disjoncteur à maxima encastré. Les bornes de montage permettent de monter l'appareil directement sur un Avo-mètre universel.

Les mesures de transistors effectuées comprennent les courants de fuite de collecteur-émetteur et de collecteur-base (I_{co}') et (I_{co}) respectivement, à un potentiel de 9 V.

Les diodes sont contrôlées dans le sens conducteur en faisant passer un courant allant jusqu'à 10 mA, en fonction de la résistance directe. Le courant inverse est contrôlé a un potentiel de 9 V.

Une mesure utile du gain de courant (β) peut être effectuée sur transistors d'une puissance atteignant 800 mW, et une indication raisonnable est donnée pour des puissances plus élevées.

Cinq courants d'entrée à base commutée sont disponibles soit 5, 10, 50, 100 et 500 μA, la tension au collecteur étant fixée à 4,5 V.

Il est possible, par l'emploi des deux jeux de bornes fournis, d'accorder ou de comparer deux transistors ou diodes similaires en un minimum de temps dans des conditions exactement pareilles.

On peut également contrôler la batterie intérieure sous charge, éliminant ainsi la possibilité d'erreurs dues à une panne de batterie.

EE 32 762 *pour plus amples renseignements*

BORNE ISOLANTE MINIATURE

Sealectro Corporation, Hersham Factory Estate, Lyon Road, Walton-on-Thames, Surrey

(Illustration à la page 254)

Cette borne isolante miniature est dotée d'un goujon barillet à corps de Teflon pour la méthode d'installation dite de "pression fixation". La longueur totale du nouvel élément est de 7,5 mm cependant que la cosse à souder mesure 3,8 mm de longueur. Le corps à châssis "direct" a un diamètre de 3.76 mm, avec une épaule d'appui de 4,26 mm de diamètre pour le châssis. La cosse à souder est en cuivre. La nouvelle borne est livrable dans toutes les couleurs courantes pour le codage de circuit.

EE 32 763 *pour plus amples renseignements*

RELAIS À PLOTS ROTATIF

Thorn Electrical Industries Ltd, Thorn House, Upper St. Martins Lane, London, W C.2

(Illustration à la page 255)

Ce relais à plots rotatif "Trois en un" se compose d'un (1) relais normal avec pivot à armature à couteau, actionnant des ressorts de contact, et mécanisme à plots entraîné par rochet, d'un (2) commutateur rotatif actionné par rochet comportant quatre bancs de 12 points chaque, avec frotteurs à ressort glissants bifurqués, et d'un (3) relais à plots entraîné par rochet, avec deux cames ouvrant et fermant des ressorts à double contact, selon le modèle des cames.

Les bornes du commutateur rotatif sont disposées en un réseau circulaire avec quatre bancs de douze points chaque. Chaque banc comprend un quart de cercle et contient un joint commun qui est relié en séquence aux 12 points

isolés au moyen d'un frotteur glissant lorsqu'on actionne le commutateur. Les quatre frotteurs glissants bifurqués sont faits en bronze phosphoreux et les assemblages de contacts à frotteurs sont isolés électriquement les uns des autres. Les contacts du banc du commutateur rotatif peuvent porter 0,5 A sur une base de régime permanent et interrompre 0,1 A à 50 V c.c. avec une charge résistive.

Le relais à plots entraîné par rochet a deux cames circulaires se partageant l'espace d'un axe commun qui actionne les frotteurs du commutateur rotatif. Chacune des deux cames actionne jusqu'à cinq ressorts de contact selon un réseau de cames prédéterminé.

Il y a, en outre, deux jeux de contacts ayant chacun un maximum de quatre ressorts qui s'ouvrent et se ferment à chaque plot du commutateur rotatif du relais à plots. Tous les ressorts de contact sont du type de ressort à longues lames avec supports pour assurer une longue durée et un fonctionnement sans ennuis. Les points de contact jumelés en métal noble peuvent recevoir 1,0 A en régime permanent et interrompre 0,5 A à 50 V c.c. avec une charge résistive.

Les tensions de bobine sont de 12, 24, 48 et 110 V c.c. Deux bobinages standards sont fournis, soit (1) une bobine d'induction réduite à action rapide pouvant régler la cadence du commutateur à 40 plots par seconde (consommation électrique: 4 W), et (2) une bobine à action lente plus sensible pouvant régler la cadence du commutateur à 20 plots par seconde (consommation électrique: 2 W).

EE 32 764 *pour plus amples renseignements*

ALIMENTATION STABILISÉE

W. G. Pye & Co. Ltd., P.O. Box 60, Cambridge

(*Illustration à la page 255*)

Ce bloc d'alimentation universel de laboratoire comporte quatre sorties principales, une alimentation haute tension stabilisée à variation continue de −10 à + 500 V, avec une sortie maximum de 250 mA, une source de polarisation stabilisée de 250 V et deux sorties de chauffage à prise médiane. Toutes ces alimentations sont "flottantes", de sorte que toutes les bornes ou n'importe lesquelles puissent être mises à la masse. Pour les tensions alternatives, elles peuvent, cependant, être reliées en série ou en parallèle. La commande de tension de la sortie de 500 V s'effectue avec la combinaison d'un commutateur à quatre positions et d'un potentiomètre, le commutateur choisissant la gamme de sortie, chaque position couvrant nominalement 125 V, et le potentiomètre assurant le contrôle continu dans chaque gamme, avec un recouvrement d'environ 10 V à chaque extrémité. A l'extrémité inférieure de la gamme de 0 à 125 V, on peut faire passer la puissance de sortie de zéro à dix volts négatifs.

Un appareil de mesure permet de lire la sortie de tension ou celle de courant provenant de l'alimentation en haute tension. La déviation sur la totalité de l'échelle de l'appareil de lecture peut être réglée automatiquement soit sur 250 V soit sur 500 V, selon la gamme de sortie utilisée.

Des sensibilités de 250 ou de 50 mA peuvent être choisies pour la lecture de courant.

Le cadran de l'appareil de lecture est gradué pour toutes ces gammes. Le bourdonnement dans l'alimentation à tension élevée est inférieur à 3 mV et le réglage supérieur à 0,1% de variation de tension de sortie pour 10% de changement d'entrée. L'impédance intérieure de l'alimentation est inférieure à 0,75 Ω du courant continu à 50 kHz.

L'alimentation de polarisation est fixée à 250 V stabilisés, et 30 mA peuvent en être tirés au besoin. Cependant, un potentiomètre relié aux bornes de l'alimentation permet d'obtenir un potentiel de polarisation variable.

Le bloc se caractérise enfin par une protection totale contre la surcharge et les courts-circuits.

EE 32 765 *pour plus amples renseignements*

DÉTECTEUR NUCLÉAIRE DE "POINTS CHAUDS"

Avo Ltd, Avocet House, 92-96 Vauxhall Bridge Road, London, S.W.1

(*Illustration à la page 255*)

Conçu pour la mesure des "points chauds" de radiations bêta gamma dans la gamme de 0.05 à 100 r/h, cet instrument sert à déterminer les points chauds de matières radioactives locales qui pourraient se déposer durant le traitement.

La chambre d'ionisation peut être montée sur n'importe quelle combinaison de trois barres prolongatrices d'enclenchement, et un connecteur souple permet à la chambre d'ionisation de se trouver à une distance allant jusqu'à 4m de l'opérateur.

La chambre d'ionisation dont le volume est de 160cm³ est une cage d'aluminium portant une feuille de "Melinex" de 0,01 mm d'épaisseur.

Une petite source de strontium 90 à l'intérieur de la chambre. ainsi que deux interrupteurs dans l'élément indicateur, permettent à l'opérateur de contrôler le fonctionnement, lorsque la chambre est dans un champ d'intensité.

EE 32 766 *pour plus amples renseignements*

ANALYSEUR DE SPECTRES

Fenlow Electronics Ltd, Springfield Lane, Weybridge, Surrey

(*Illustration à la page 255*)

Cet instrument a été étudié pour l'analyse des formes d'ondes enregistrées de vibrations, de contraintes, etc., telles qu'on les trouve dans l'industrie mécanique. La gamme de fréquences de l'analyseur va de 0,3 Hz à 1050 Hz. Il est portatif, autonome et fonctionne sur courant secteur de 200 à 240 V 50 Hz. La fonction principale de cet appareil est de repérer et de mesurer les périodicités dissimulées dans les enregistrements.

Il comprend un indicateur incorporé montrant la puissance de la forme d'onde aléatoire dans la bande utile à laquelle l'appareil est réglé. On peut, d'autre part, supprimer le signal après le filtrage aux fins d'enregistrement, si nécessaire.

Cinq largeurs de filtre sont prévues, donnant des largeurs de bande de 0,06 Hz à 37,5 Hz. Les temps de filtrage pouvant être adaptés à la largeur de bande utilisée vont de 1,5 à 150 secondes.

Il se distingue par plusieurs caractéristiques nouvelles et assure une analyse utile et précise des données d'entrée. C'est plutôt un dispositif à largeur de bande constante qu'un dispositif a valeur Q constante, utilisant le système à hétérodyne avec filtres à sortie passe-bas et deux canaux de quadrature pour prévenir les ambiguités dues à la synchronisation de phase pour les entrées quasi périodiques. Des couples thermoélectriques quadratiques précis sont utilisés pour mesurer la puissance, et ils sont suivis par l'élément de filtrage avec des temps de filtrage contrôlables.

Les commandes et le compteur de sortie sont sur le panneau frontal incliné, de même que les bornes d'entrée et de sortie. Des points de contrôle sont obtenus en enlevant le capot. Vu que l'analyseur de spectres contient sept amplificateurs de fonctionnement, on peut donc les utiliser pour d'autres usages lorsque l'instrument n'est pas affecté à l'analyse. Ils peuvent être employés, par exemple, pour simuler les équations d'un système mécanique.

EE 32 767 *pour plus amples renseignements*

RELAIS INTERCHANGEABLE

The Keyswitch Company, 2 Irongate Wharf Road, Praed Street, London W.2

(*Illustration à la page 256*)

Le relais interchangeable P-32 est fourni avec n'importe quel relais du type 3000 conforme aux spécifications postales normales, c'est à dire de 2 à 18 ressorts (1 contact de travail pour 6 commutations).

Les contacts peuvent être en argent double (300mA), en palladium double ou en platine double (1A), en argent fin de grande résistance (2A), en oxyde cadmié argenté ou en nickel argenté (8A).

Les caractéristiques de fiche et doville sont de 250V c.a. ou c.c. Le contact positif est net enre broches mâle et femelle. Une bride maintient le relais positivement dans n'importe quelle position.

Le relais est livré complet avec couvercle transparent ou métallique et douille.

EE 32 768 *pour plus amples renseignements*

RELAIS DE VERROUILLAGE

Electrical Remote Control Co. Ltd, Elmreco Works, Bush, Harlow, Essex

(*Illustration à la page 256*)

Le relais de verrouillage type UNIV/LA qui peut porter jusqu'a huit jeux de contacts, normalement ouverts, normalement fermés, commutés ou

mixtes, est maintenu par un simple mécanisme de verrouillage dans la position d'excitation, après l'application d'une courte impulsion à la bobine. Lorsqu'on presse le levier fixé au relais, les contacts sont déclenchés dans la position désexcitée, y demeurant jusqu'à ce qu'une nouvelle impulsion soit appliquée à la bobine.

Le relais de verrouillage UNIV/LA/S (voir notre gravure) est semblable au modèle à réenclement manuel décrit ci-dessus, mais il peut être verrouillé et déverrouillé par impulsion électrique. Il est fixé sur une plaque servant également de support de montage. Cette plaque porte aussi une petite solénoïde qui déclenche le dispositif de verrouillage lorsqu'elle est excitée.

La gamme de bobines disponibles s'étend jusqu'à une puissance de 440 V c.a. ou 230 V c.c. Les valeurs nominales des contacts sont de 6 A, 230 V. c.a. ou 2 A. 440 V c.a. ou encore 1 A, 240 V c.c.

EE 32 769 *pour plus amples renseignements*

CALIBRE D'ÉPAISSEUR À ULTRA SONS

Distributeurs: Aveley Electric Ltd, Ayron Road, Aveley Industrial Estate, South Ockendon, Essex

(Illustration à la page 256)

La jauge d'épaisseur à ultra sons, Kretz type 6000, comporte un amplificateur à large bande de grande stabilité à gamme de fréquences de 3 MHz à 20 MHz, et elle a été spécialement conçue pour donner la possibilité de mesurer avec précision la dilatation ou la contraction. Elle est dotée d'un circuit de déclenchement spécial dont le rôle est d'avertir lorsqu'une limite prédéterminée de mesure a été atteinte.

Les mesures d'epaisseur s'obtiennent avec précision en reliant plusieurs impulsions par une base mobile dont le bord principal peut être déplacé de manière à diviser le premier cycle de chaque impulsion d'appel. Plus le nombre d'impulsions d'échos utilisées pour la mesure est élevé, plus la discrimination obtenue est élevée. La réponse de déviation verticale de la trace est supérieure à 0.05 microsecondes, de sorte que l'on obtient une discrimination durée/écho de 0,0125 microsecondes.

L'appareil a une gamme de profondeur effective de 1 cm à 70 cm pour la détection des défauts dans le métal. Pour la mesure d'épaisseur, sa gamme maximum est de 20 mm, selon la fréquence et l'atténuation du matériau soumis à l'essai. La consommation électrique est de 180 VA. Une prise de faible tension est prévue pour certains genres de travaux exigeant des mesures de précaution électriques des plus strictes. L'emploi de cette prise rend automatiquement inopérante la connexion de haute tension.

EE 32 770 *pour plus amples renseignements*

ÉLÉMENT DE SIGNAUX CARRÉS

Feedback Ltd, Crowborough, Sussex

(Illustration à la page 256)

L'élément de signaux carrés type SW98 fabriqué par la société Feedback Ltd, qui est une filiale de Servomex Controls Ltd, fournit un signal carré d'excitation aux calculateurs analogiques à répétition. Un signal carré est fourni à la fréquence secteur et l'instrument produit églalement des ondes carrées à partir d'ondes sinusoïdales appliquées extérieurement dans la gamme de fréquences de 50Hz à 10 kHz. Le temps de montée est d'environ 2 μsec pour n'importe quelle fréquence de fonctionnement et un trimmer de rapport marque/espace permet d'obtenir un rapport 1 : 1 exact.

Le signal externe minimum pour un fonctionnement satisfaisant est de 2 V de puissance de crête et la sortie est a réglage continu de 0 à 50 V crête à crête, indépendamment de l'amplitude d'entrée.

Un circuit accordé a été incorporé pour produire une oscillation d'étalonnage pour la mesure de temps sur une trace oscilloscopique pouvant être utilisée avec des calculateurs analogiques à répétition. La fréquence d'étalonnage est de 2,5 kHz et le train d'oscillations peut être déclenché de manière à coïncider avec la monitié positive ou négative du signal carré.

EE 32 771 *pour plus amples renseignements*

APPAREILS DE MESURES INDUSTRIELLES

Ekco Electronics Ltd, Southend-on-Sea, Essex

Trois nouveaux instruments Ekco viennent d'être spécialement créés pour les procédés industriels. La jauge d'humidité type N 680 a été principalement conçue pour les machines à fabriquer du papier et indique avec précision le degré d'humidité dans le papier, dans une gamme de 2 à 75% de teneur d'humidité. Il existe, en variante, des modèles donnant des gammes limitées, telles que 2 à 15% et 60 à 75%. L'appareil peut être utilisé comme contrôleur d'humidité à l'extrémité sèche de la machine et il peut également être utilisé en liaison avec la jauge de substance Ekco à l'extrémité humide. Cette dernière application permet de mesurer le poids de la substance sèche à un stade de fabrication où il était impossible de le faire auparavant.

L'appareil de mémoire type N682, principalement conçu pour les revêtements, donne une lecture de jauge pour un temps préréglé, en rapport avec le procédé de fabrication, grâce à un dispositif qui synchronise le retard avec la vitesse de la machine. Ceci permet de comparer une lecture de matière revêtue. Grâce au retard donné par l'appareil de mémoire, les lectures "revêtues" et "non revêtues" pour une même superfice de matière, peuvent être comparées après le processus de séchage ou de durcissement. Les signaux de différence sont ensuite appliqués à un dispositif de contrôle automatique actionnant des moteurs vissés sur le rouleau plongeur ou la lame racleuse. Des lectures directes des poids de revêtement appliqués peuvent également être données sur un appareil de mesure ou un enregistreur à bande.

La lecture continue et précise des métaux produits en bandes, ayant jusqu'à 1,27cm d'épaisseur est fournie par la jauge à rayonnements secondaires type N658, dans laquelle les rayons X sont engendrés sous forme de rayonnements de freinage à partir d'une source de strontium 90. Le bloc incorporé de contrôle automatique type N604 assure le contrôle entièrement automatique.

EE 32 772 *pour plus amples renseignements*

MICRORUPTEUR ÉLECTRONIQUE

Servo Consultants Ltd, 10 Bouverie Place, London, W.2

(Illustration à la page 257)

Cet élément a été réalisé pour répondre à la nécessité de pouvoir compter sur un dispositif robuste et sans contacts pour synchroniser le fonctionnement du matériel automatique. Il est essentiellement destiné à jouer le rôle d'un paire de contacts électriques, actionnés mécaniquement par une came sur une machine. Le mécanisme sélectif de la came ne contient pas de pièces mobiles et sa durée est donc extrêmement longue. Tous les composants électroniques utilisés ont des caractéristiques généreuses, et le dispositif entier est fabriqué de façon à pouvoir résister aux conditions de vibrations extrêmes rencontrées dans de nombreuses applications industrielles.

Il peut être mis en mouvement par came mobile ou par tout appareillage analogue, la condition essentielle étant que cet appareillage soit en matière magnétique. L'espace normal entre l'extrémité frontale du microrupteur et la came peut varier entre 0 et 0,030 pouces dans les conditions de "marche", et devrait dépasser 0,25 pouces dans les conditions "d'arrêt". Les conditions de "marche" et "d'arrêt", sont purement arbitraires et le dispositif peut rester indéfiniment dans l'un ou l'autre de ces deux états. Sa gamme de réponses s'étend donc du fonctionnement sur courant continu à environ 1000 tours/minute. La précision de définition est de 0.5 mm, donnant une précision angulaire d'environ 25 minutes d'arc lorsqu'on emploie une came de 150 mm de diamètre.

EE 32 773 *pour plus amples renseignements*

KLYSTRONS MILLIMÉTRIQUES

Elliott Brothers (London) Ltd, 34 Portland Place, London, W.1

Quatre nouveaux oscillateurs klystrons pour les bandes de 4, 6 et 12 mm ont été réalisés par Elliott Brothers.

Ces klystrons, qui sont à refroidissement par eau et fabriqués selon le principe du tube de glissement flottant,

produisent des signaux de sortie exceptionellement exempts de glissement thermique et d'hystérésis. Le verre utilisé dans la fabrication des enveloppes a un point de ramollissement à température élevée, et il est scellé au molybdène. Cette dernière particularité, permet de cuire les tubes à 700°C durant le processus de fabrication et résulte en un vide extrêmement poussé, de bonnes caractéristiques de bruit réduit et une durabilité cathodique amelioŕée. La durée moyenne est de 500 heures au minimum.

Le modèle 4FK1, qui comporte bon nombre des composants utilisés dans le klystron 8FK1 de bande Q à 15 W peut assurer une sortie de puissance supérieure à 100 mW à une fréquence fixe d'environ 75 kMHz.

Deux klystrons sont actuellement en production pour la bande de 6 mm: le 6FK1, un oscillateur à fréquence fixe qui livre une sortie de puissance d'environ 2 W à 50 kMHz, et le 6TFK2, qui est une version accordable du 6FK1.

Le 12TFK2, un nouvel oscillateur de 12 mm, est une version accordable de l'oscillateur à fréquence fixe 12FK1 de 10 W. Il assure une sortie de puissance de 8 W au minimum dans une gamme de 1000 MHz centrée dans la bande de 21 à 25 kMHz.

EE 32 774 *pour plus amples renseignements*

REDRESSEURS AU SILICIUM

International Rectifier Co. (Great Britain) Ltd, Hurst Green, Oxted, Surrey

(Illustration à la page 257)

Une nouvelle gamme d'assemblages de redresseurs au silicium de puissance moyenne est maintenant offerte par la International Rectifier Co. (G.B.) Ltd. Cette série s'adapte aux sorties les plus communes d'alimentations de matériels tels que les amplificateurs de puissance, l'équipement d'émissions radio, les blocs d'alimentation de calculateurs, etc.

Les assemblages livrables sont dans les configurations monophasées mi-onde, monophasées en pont et triphasées en pont, et leur efficacité va jusqu'à 98%, ce qui réduit les problèmes de chauffage. Leur rapport sortie/grandeur élevé les rend facilement interchangeables dans les matériels déjà en usage et réduit au minimum l'espace nécessaire dans les matériels nouveaux. Tous les assemblages sont de construction robuste avec ailettes et bornes "à verrou", rainures de montage à extrémité ouverte et bornes à code de couleurs.

EE 32 775 *pour plus amples renseignements*

TUBES DE PUISSANCE HAUTE FRÉQUENCE

Associated Electrical Industries Ltd, 155 Charing Cross Road, London, W.C.2

(Illustration à la page 257)

Une nouvelle méthode de refroidissement qui serait plus efficace que les précédentes et rendrait les tubes plus économiques à installer et plus faciles à entretenir est incorporée dans trois nouveaux tubes de puissance haute fréquence Ediswan refroidis par eau. Au lieu de la chemise de refroidissement classique, un tube à eau en cuivre en spirale est fixé directement à l'anode. Les tubes sont du type 15P12 avec une dissipation anodique maxima de 0,6 kW et une sortie de puissance haute fréquence maxima de 2,5 kW, ainsi que des types 16P12 et 16P13, tous deux d'une dissipation anodique maxima de 3 kW et d'un sortie de puissance haute fréquence maxima de 7,5 kW.

Grâce à l'absence de scellements, le risque de fuites d'eau est considérablement réduit. Le tube complet est, dans chaque cas, plus compact que les types analogues à refroidissement conventionnel. La consommation d'eau est faible, c'est à dire d'environ 1 litre pour 3 kW de dissipation anodique. Un dispositif breveté de protection contre la surdissipation est incorporé au tube.

Les suffixes 12 et 13 dénotent le type de couplage d'eau prévu, le type 16P12 étant, par exemple, connecté par souplisso, et le type 16P13 par joints.

Le 15P12 comporte une grille en matériau nouveau non-émetteur.

EE 32 776 *pour plus amples renseignements*

Résumés des Principaux Articles

Un calculateur analogique pour diagrammes de rayonnement d'antenne par H. Page, G. J. Phillips et J. A. S. Fox

Résumé de l'article aux pages 206 à 212

Un calculateur analogique a été construit pour calculer les diagrammes de rayonnement horizontal de réseaux d'antennes comprenant un certain nombre d'éléments rayonnants, montés sur un mât de support central. Il suffit de connaître le diagramme de rayonnement d'un seul élément pour pouvoir calculer le diagramme d'un nombre d'éléments identiques autour du mât. Les courants dans les éléments peuvent avoir n'importe quelle phase ou amplitude voulue.

Le principe mis en oeuvre consiste à ajouter un certain nombre de tensions de basse fréquence, chaque composante représentant le rayonnement d'un élément vers une direction particulière. Par l'utilisation d'un banc de commutateurs rotatifs, les sommations appropriées sont effectuées à tour de rôle pour des relèvements à des intervalles de 7,5° ou 15°, le résultat étant indiqué sur un appareil de mesure. Le calculateur peut être adapté à d'autres types d'indicateur visuel.

Un bloc de commande asservi tous courants à action rapide par B. A. Unvala et B. T. Denvir

Résumé de l'article aux pages 213 à 217

Le prototype de bloc asservi décrit dans cet article peut actionner un moteur asservi courant alternatif de 10W à partir d'une entrée à basse tension dans la gamme de fréquences allant du courant continu à 70Hz. Le circuit comprend un modulateur en anneau à diode branché sur 400Hz, suivi d'un

amplificateur à courant alternatif comportant des réseaux déphaseurs et limiteurs. Le modulateur est à redresseurs au silicium et l'amplificateur, entièrement transistorisé, est exclusivement muni de transistors au silicium. Le circuit d'alimentation est également décrit dans cet article.

Transmissions à grande distance à partir de guides d'ondes circulaires, par la modulation de fréquence par R. Hamer

Résumé de l'article aux pages 218 à 225

L'auteur examine les possibilités d'effectuer des transmissions à grande distance à partir de guides d'ondes circulaires (Onde H_{01}) au moyen de la modulation de fréquence, en présupposant une structure de guide d'onde particulière et des imperfections aléatoires dans le guide d'ondes. Les limites fondamentales sont les suivantes :

(a) atténuation accrue du mode H_{01} dû à la transformation du mode en cas d'imperfections dans le guide d'ondes.

(b) distorsion d'intermodulation provoquée par la débit en parallèle et les signaux d'échos.

(c) dispersion dans le guide d'ondes.

Cette analyse se rapporte en particulier aux transmissions téléphoniques multivoies, vu que ces dernières présentent la plus grande difficulté; le signal de modulation et simulé par bruit erratique.

Les résultats de l'analyse sont appliqués à une voie hypothétique comprenant des sections jointes aléatoirement formées de tubes de cuivre de 5cm de diamètre revêtus d'un enduit diélectrique. Le bruit d'intermodulation qui en résulte dans une des voies téléphoniques d'un réseau à 2700 voies en est déduit pour une série de paramètres, à une fréquence porteuse de 35GHz.

L'auteur en conclut que les susdites limites n'excluent pas l'utilisation de la modulation de fréquence dans les transmissions à grande distance par guide d'ondes circulaire.

Le choix et la réalisation de convertisseurs de courant par J. S. Bell et P. G. Wright

Résumé de l'article aux pages 226 à 231

L'auteur traite de la réalisation des convertisseurs à transformateur unique et à deux transformateurs et compare leur comportement. Il indique des procédés d'étude, et décrit en détail, à titre d'exemples, deux réalisations pratiques.

Convertisseur linéaire-logarithmique pour compteur linéaire par J. Turnbull et D. N. Walder

Résumé de l'article aux pages 238 à 239

Les auteurs décrivent un convertisseur qui, lorsqu'il est alimenté par un étage à echelle de 2, capable d'engendrer des ondes carrées à direction négative (30V d'amplitude), peut donner une sortie approximativement logarithmique dans deux décades. Par commutation, on peut obtenir une déviation sur la totalité de l'échelle du compteur de sortie dans une gamme de comptage de 10 à 1000 ou de 100 à 1000 impulsions par seconde. Des sorties d'enregistrement existent pour 5mA ou 100mV.

Une commande précise de fréquences pour convertisseur rotatif par M. J. Tucker

Résumé de l'article aux pages 240 à 241

Le navire royal de recherches "DISCOVERY II" a été doté d'une alimentation de 50Hz dont la précision de fréquence peut être d'environ 1 partie dans 10^5 en bloquant la phase d'un petit convertisseur rotatif sur celle d'un signal de référence de 50Hz provenant d'un oscillateur piloté par quartz.

Une nouvelle commande de niveau de courant continu pour systémes d'adaptation par R. A. Johnson et J. D. Hill

Résumé de l'article aux pages 242 à 244

Le nouveau circuit électronique qui fait l'objet de cet article, maintient sensiblement constante la chute de tension dans une charge, tout en permettant de varier le niveau de courant continu de la charge dans une gamme étendue. Ce circuit n'exige que des composants électroniques à tolérance ordinaire et atteint un haut niveau de précision grâce à un dispositif de compensation d'erreurs.

Le modèle de réalisation qui est présenté autorise le passage d'une charge de 20 k Ω à travers 200V, tout en maintenant la tension de 200 volts constante à ± 0,2% près.

ELEKTRONISCHE GERÄTE

Beschreibung neuer Bauelemente, Zubehörteile und Prüfgeräte auf Grund der von Herstellern gemachten Angaben.

Übersetzung der Seiten 252 bis 257

DIGITALVOLTMETER

Solartron Laboratory Instruments Ltd, Cox Lane, Chessington, Surrey

(Abbildung Seite 252)

Im Digitalvoltmeter Type 902.2 werden Gleichspannungen von 100 μV bis zu 1,500 kV vierziffrig in Dezimalform mit Polaritätsunterscheidung angezeigt. Die Anzeige erfolgt durch optische Projektion und ist frei von der Mehrdeutigkeit, mit der einige der Digitalanzeigesysteme behaftet sind. Roter bzw. schwarzer Hintergrund zeigt positive bzw. negative Eingänge an.

Die Spannungsmessungen erfolgen in fünf Bereichen. Der Eingangswiderstand ist 100 MΩ für die drei höchsten Bereiche und 1 MΩ bzw. 100 kΩ für die zwei niedrigeren. Die Dauergenauigkeit ist ±0,1% der Höchstanzeige für jeden Bereich. Zwei zusätzliche Spannungsbereiche für 100 V und 1 kV haben 100 MΩ Eingangswiderstand und ±0,5% Messgenauigkeit.

Die Einstellzeit ist mit 280 ms konstant und unabhängig von angelegten Spannungen, die bis zu 700 V erdfrei sein können.

Eine "Kontroll"-Stellung am Bereichschalter ermöglicht Nullstellung und Nacheichung. Die interne Zener-Bezugsspannung kann auf ihren genauen Wert eingestellt und wenn nötig nach Vergleich mit der eingebauten Weston Normalzelle nachgestellt werden.

Bei normalem (automatischem) Betrieb werden die Spannungen laufend gemessen, und jede Schwankung verursacht eine Anzeigeänderung. Um den Anwendungsbereich so vielseitig wie möglich zu machen, wurde im LM 902.2 eine einstellbare "tote Zone" vorgesehen, die innerhalb gewisser Grenzen das Gerät gegen geringe Spannungsschwankungen unempfindlich machen kann. Dadurch können selbst bei Vorhandensein von Einschwingvorgängen zitterfreie Ablesungen vorgenommen werden. Die vorhandene Netzrestwelligkeit der zu messenden Spannung kann daher durch Einschaltung einer kurzen oder langen Zeitkonstanten in den Eingangskreis gedämpft oder gesperrt werden.

Durch Umschaltung auf "Sampling" wird bei Drücken eines Knopfes auf der Frontplatte oder Fernsteuerung eine Einzelablesung der Spannung vorgenommen. Diese Anzeige bleibt stehen, bis die nächste Probenahme erfolgt.

Der 50poligen Ausgangsbuchse auf der Rückseite können Digitaldaten in Dezimalverschlüsselung, Polaritäts- und Druckbefehlssignale zur Speisung eines Venner-Druckwerkes TSA 65 und zusätzlicher Anzeigegeräte entnommen werden.

EE 32 751 *für weitere Einzelheiten*

DRAHTPOTENTIOMETER

Painton & Co. Ltd, Benbridge Drive, Kingsthorpe, Northampton

(Abbildung Seite 252)

Das neuste Bourns "Trimpot"-Modell Nr. 224 wird von der Painton & Co. Ltd. in den Werken in Northampton hergestellt.

Das 31,75 mm lange Drahtpotentiometer hat eine Betriebstemperatur von 175°C und ist gegen Feuchtigkeit, Flüssigkeiten und Ausgiessharz isoliert.

Eine 22gängige, selbstsichernde Schraubenziehereinstellung hat ausgezeichnete Stoss-, Erschütterungs- und Beschleunigungsfestigkeit: das präzisionsgewickelte Element gewährleistet hohe Betriebssicherheit. Bei 70°C ist die Verlustleistung 1 W und bei 125°C 0,5 W. Widerstandswerte bis zu 100 kΩ können geliefert werden.

Drei Anschlussausführungen sind vorgesehen: isolierte Drahtenden, Lötfahnen und Stifte für gedruckte Schaltungen.

EE 32 752 *für weitere Einzelheiten*

DEUTSCHE INDUSTRIE-MESSE HANNOVER

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HALLE 13 STAND 2

Besucher sind herzlich willkommen.

MINIATUR-TRANSISTORVERSTÄRKER

Amplivox Ltd, Beresford Avenue, Wembley, Middlesex

(Abbildung Seite 252)

Amplivox stellt eine Reihe kleiner NF-Verstärker unter Benutzung einer Miniatur-Technologie her, die Mikro-Schaltungs-Abmessungen erzielt. Bei Verwendung herkömmlicher Verdrahtungsmethoden werden Bauelementdichten von mehreren hundert pro Kubikzoll erreicht.

Mit dem abgebildeten grösseren Verstärker kann in einer Kohlemikrofonschaltung für bessere Sprachdeutlichkeit und höheren Rauschabstand ein magnetisches Miniaturmikrofon benutzt werden. Der Verstärker ist in den verschiedensten Ausführungen lieferbar und entspricht in seiner hermetisch gekapselten Form den Klima-Prüfvorschriften des Ministeriums.

Das Subminiaturgerät ist ein mit drei Transistoren bestückter Verstärker auf einer 12,7 × 5 mm Leiterplatte und hat eine Bauelementdichte von ungefähr 20/cm³. Die durch Gegenkopplung stabilisierte Verstärkung ist 76 dB und die Ausgangsleistung ungefähr 1 mW in 600Ω.

EE 32 753 *für weitere Einzelheiten*

WANDERFELD-RÖHREN FÜR 6 GHz

General Electric Co. Ltd, Magnet House, Kingsway, London, W.C.2

M-O Valve Co. Ltd, eine Tochtergesellschaft der G.E.C., hat die Herstellung einer neuen Type in der Serie der Wanderfeld-Röhren mit Wechselfeldfokussierung aufgenommen.

Es handelt sich um die G.E.C. TWC5, eine Wanderfeld-Röhre, die als Leistungsverstärker im 5925...6425 MHz Band 15 W abgeben kann.

Die G.E.C. TWC5 wurde besonders für das Mehrkanal-Fernmeldesystem entwickelt, das in diesem Trägerfrequenzbereich betrieben wird; die zulässige Bandbreitenüberstreichung kann jedoch wesentlich grösser sein.

Ein Hauptmerkmal, das gegenüber vergleichbaren Röhrentypen einen wesentlichen Vorteil zeigt, ist die Leichtigkeit, mit der der magnetische Wechselfeldkreis ausgewechselt werden kann. Durch straffe Fertigungskontrolle der Bauelemente aus Metall und Glas und sorgfältig ausgearbeitete Pumppläne verspricht die Röhre lange Lebensdauer und hohe Betriebssicherheit. Sie wird daher den schärfsten Ansprüchen des Fernmeldesystems genügen.

EE 32 754 *für weitere Einzelheiten*

HOCHVAKUUM-DREHKONDENSATOREN

English Electric Valve Co. Ltd. Waterhouse Lane, Chelmsford, Essex

(Abbildung Seite 253)

Die English Electric Valve Co. Ltd hat Hochvakuum-Drehkondensatoren angekündigt, die wahrscheinlich die ersten in Grossbritannien handelsmässig lieferbaren sind. Das Programm besteht aus 5 Typen, von denen drei Kapazitäten von 5...30, 8...50 und 16...80 pF und zwei Kapazitäten von 5,5...206 pF haben. Für die ersten drei ist die HF-Spitzenspannung 15 kV und für die anderen beiden 8 bzw. 10 kV.

Durch Verwendung des Hochvakuums als Dielektrikum kann der Plattenabstand bei vergleichbaren Nennwerten auf ein Zehntel des Abstandes mit Luftdielektrikum herabgesetzt werden und ergibt somit einen äusserst kompakten Aufbau. Trotzdem kompakte Konstruktion selbst besonders für Flug- und Militärzwecke schon ein grosser Vorzug ist, sind die dadurch hervorgerufenen Vorteile geringer Streukapazität und -induktivität des Vakuumkondensators von weiterer grosser Bedeutung für Konstrukteure von HF-Schaltungen für Runfunk-, Verkehrs- und Industriegeräte.

Konstruktionsmässig wird das Prinzip des bekannten Hochvakuum-Festkondensators weiterverfolgt, in dem das Kondensatorelement aus sich überdeckenden konzentrischen Zylindern besteht. Der Drehkondensator benutzt jedoch einen Metallbalg, der einen Teil des Vakuumgefässes bildet, um eine axiale Bewegung zur Änderung der Überdeckung auf einen Zylindersatz zu übertragen. Die Bearbeitung und der Zusammenbau des Metallbalges spielt in der Herstellung der Kondensatoren eine wesentliche Rolle. Durch die Konstruktion selbst wird eine lineare Kapazitätskennlinie bis auf die Mindestkapazität gewährleistet, für die Randeffekte zu einer kleinen Abweichung führen. Der grösste Kondensator hat Abmessungen von nur 241 × 89 mm, und alle Kondensatoren erfüllen die Forderungen der Norm RCS11.

EE 32 755 *für weitere Einzelheiten*

FEUCHTIGKEITSMESSER

Kappa Electronics, 159 Hammersmith Road, London, W.6

(Abbildung Seite 253)

Der Kappa Feuchtigkeitsmesser Type AB/55 ist für schnelle und genaue Ermittlung des Feuchtigkeitsgehaltes einer grossen Anzahl von Materialien bestimmt.

Das Gerät ist frequenzempfindlich und misst die Dielektrizitätskonstante des Inhaltes einer auswechselbaren Prüfzelle in willkürlich festgelegten Einheiten. Die Dielektrizitätskonstante hängt von den physikalischen Eigenschaften und dem Feuchtigkeitsgehalt des Materials ab. Eine durch Schwankung des Feuchtigkeitsgehalts hervorgerufene Frequenzänderung wird in einer Überlagerungsschaltung genau nachgewiesen und auf einer kontinuierlichen Skala angezeigt, die für 1000 klar getrennte Teilstriche geeicht ist.

Die Prüffrequenz des Gerätes ist so gewählt, dass die Anzeige nicht durch die Leitfähigkeit beeinflusst wird; Prüfzellen verschiedener Grösse stehen zur Verfügung, um zu gewährleisten, dass das Muster wirklich der Gesamtmenge des Materials entspricht.

Für übliche Materialien leidlich konstanter Zusammensetzung und Struktur kann eine Genauigkeit erwartet werden, die für den Feuchtigkeitsbereich 0...20% zwischen 0,05 und 0,4, den Bereich 20...30% zwischen 0,2 und 0,5, den Bereich 30...40% zwischen 0,3 und 0,7 und den Bereich über 40% zwischen 0,5 und 1,0 liegt.

EE 32 756 *für weitere Einzelheiten*

KLEINSTPOTENTIOMETER

Egen Electric Ltd, Charfleet Industrial Estate, Canvey Island, Essex

(Abbildung Seite 253)

Dieses neue Baumuster im Egen-Potentiometerprogramm wurde besonders für Transistor-Schaltungen entwickelt und hat viele Konstruktionsmerkmale, die für das Gebiet der Miniaturisierung interessant sind. Sie sind robust konstruiert mit Spritzgusskörper von nur 12,7 mm Durchmesser, Einlochbefestigung und zäher Isolierstoffachse von 4,8 mm Durchmesser und in den bevorzugten Widerstandswerten zwischen 1 kΩ und 3 MΩ mit linearer oder logarithmischer Regelkurve lieferbar. Anfänglich werden zwei Ausführungen hergestellt: Type 363 ohne Schalter und Type 365 mit zweipoligem Kippschalter. Beide Ausführungen haben Lötfahnenanschlüsse. Weitere Ausführungen für gedruckte Schaltungen sind für Produktion in Kürze vorgeplant.

EE 32 757 *für weitere Einzelheiten*

ÜBERTRAGUNGSSYSTEM FÜR DIGITALE DATEN

Ericsson Telephones Ltd, Beeston, Nottingham

(Abbildung Seite 253)

Die Einführung zentralisierter Rechneranlagen erforderte Bereitstellung geeigneter Datenübertragungssysteme von getrennten und weit verteilten Punkten und dem Rechnerzentrum. Fernsprech- und Fernschreiberleitungen bestanden zwar in vielen Fällen, waren aber für den grossen Verkehrsumfang unzulänglich.

Das Übertragungssystem für digitale Daten benutzt elektronische Mittel, durch die binäre Daten mit Geschwindigkeiten bis zu 500 Baud über Träger wie z.B. das normale Fernsprechnetz oder Privatleitungen übertragen werden können.

Die Geräte an der Sendeseite bestehen aus einer Eingabevorrichtung wie z.B. ein Magnetband- oder Lochstreifenleser und einem FM-Sender. Ein fehlerberichtigender Schlüssler ist eingebaut, um Fehler zu eliminieren, die durch in den meisten Fernsprechsystemen auftretende vereinzelte Störstösse entstehen. Die Anlage der Empfangsseite besteht aus einem Verstärker und Detektor mit nachgeschaltetem fehlerberichtigenden Entschlüssler. Sowohl Sender wie auch Empfänger sind für Fünferlochstreifen ausgelegt, jedoch können sie auf Wunsch durch einfache Abwandlung dem 6-, 7- oder 8-Loch-Code oder anderen Trägern angepasst werden. Das empfangene und entschlüsselte Signal kann in Serien- oder Parallelform ausgegeben werden und über geeignete Pufferspeicher Lochstanzen, Magnetbandgeräte oder Druckwerke speisen. An der Sendeseite können Einrichtungen vorgesehen werden, die anzeigen, ob die Anlage fehlerfrei arbeitet und betriebsfertig ist. An der Empfangsseite kann eine Einrichtung die Verbindung nach Beendigung der Übertragung automatisch freigeben.

Sowohl Sender wie Empfänger sind volltransistorisiert und aus hochwertigen Bauelementen konstruiert. Daher ist das System betriebssicher und wirtschaftlich in Betriebskosten.

Sender und Empfänger können entweder für Montage in 19 Zoll-Gestellen oder in Gehäusen geliefert werden.

EE 32 758 *für weitere Einzelheiten*

IMPULS-SCHNELLSCHALTER

Lancashire Dynamo Electronic Products Ltd, Rugely, Staffordshire

(Abbildung Seite 253)

Dieses neue elektromechanische Schaltgerät wurde entwickelt, um von einer umlaufenden Welle mittels nockengesteuerter Hochleistungsschalter elektrische Kreise schalten zu können.

Das Gehäuse aus gegossenem Leichtmetall ist spritzerfest und kann mittels eines Fusses oder Flansches anmontiert werden, die beide am Gehäuse angegossen sind. Der Schalter wird durch eine ¼" (9,5 mm) Eingangswelle getrieben, die an den beiden Gehäuseenden in abgedichteten Lagern läuft. Zwei Hochleistungs-Blattfederkontaktsätze sind vorgesehen. Die Arbeitsweise hängt von der Nockenform ab.

Der Drehschalter ist in erster Linie für Einsatz mit dem elektromagnetischen Schnellzähler Baumuster F43 bestimmt, ist aber auch mit einer anderen Nockenform als Grenzschalter für umlaufende Ventilschieber und ähnliche Zwecke geeignet.

EE 32 759 *für weitere Einzelheiten*

MOTORGETRIEBENER FERNSEH-KANALSCHALTER

The Plessey Co. Ltd, Vicarage Lane, Ilford, Essex

(Abbildung Seite 254)

Die Plessey Company hat einen neuen, motorgetriebenen Kanalschalter für alle Fernseh- und FM-Kanäle herausgebracht. Das neue Bauelement Typ PL14M erleichtert die Anwendung von Fernsteuerung und Drucktastentechnik für Heimempfänger. Die Drucktasten schalten nur elektrische Kreise und sind nicht mechanisch belastet.

Der HF-Oszillatorteil ist mit den neuesten Spanngitterröhren bestückt und hat hohe Verstärkung, geringes Rauschen und geringe Drift.

Eine neuartige Kontaktkonstruktion im Kanalschalter gibt genaue Wiedereinstellung mit geringster Frequenzdrift. Für Sonderzwecke kann jedoch auf Wunsch eine Scharfabstimmung vorgesehen werden.

Zur Vermeidung von Störungen wird der Induktionsmotor im besonders entwickelten Antriebsteil aus dem Netz gespeist. Genaue Wiedereinstellung durch Selbstrasten des Kanalschalters und automatische Unterbrechung, um Durchrutschen nach Abschalten des Motors zu vermeiden, werden durch eine Sonderkupplung erreicht.

Der motorisierte Kanalwähler kann in jeder Position im Empfänger eingebaut werden, da diese nicht durch externe Bedienungsknöpfe bestimmt wird.

Der Schalter wird in 7 Sekunden durch 360° gedreht.

EE 32 760 *für weitere Einzelheiten*

TRANSISTOR-ANALYSATOR

Microcell Electronics Ltd, Blackwater, Camberley, Surrey

(Abbildung Seite 254)

Dieses Gerät ist zur sehr genauen Parametermessung von pnp und npn Transistoren ausgelegt, und verschiedene eingebaute Messanordnungen sind besonders wertvoll für Schaltungsingenieure, die genauere Information über einzelne Transistoren brauchen, die von Herstellern normalerweise nicht erhältlich ist. Es ist auch besonders zum Aussuchen von Transistor-Pärchen geeignet.

Folgende Parameter können gemessen werden: Verstärkungsfaktor β, Grenzfrequenz f'_{co}, Kollektorsperrstrom I'_{co} und Kollektordurchschlagsspannung V_{ot} von Transistoren in Emitter-Schaltung sowie I'_{co} und V_{to} von Dioden.

Konstruktionsmerkmale des Gerätes umfassen Verwendung einer Differentialeingangsschaltung, eines Breitbandvoltmeters für die β-Anzeige und eines Breitbandoszillators als Signalquelle. Die Röhrenvoltmeter-Anzeige hebt wirksam die Fehler auf, die durch Nebenspannungen in den Verhältnisnetzwerken entstehen. Der Frequenzgang dieses Röhrenvoltmeters liegt innerhalb ±1,5 dB über den Bereich von 1 kHz...10 MHz. Der Wienbrücken-Oszillator überstreicht den Bereich von 1 kHz...10 MHz und hat eine Amplitude, die innerhalb ±1,5 dB konstant gehalten wird. Die Stromversorgung für den Kollektor sowie für den Oszillator und das Röhrenvoltmeter ist vollstabilisiert.

Kollektorspannung und -strom werden mit Profil-Messgeräten überwacht, die so übereinander angeordnet sind, dass sie beide gleichzeitig beobachtet werden können. Sie haben ausreichenden Überlastungsschutz; der Basisstrom kann durch ein eingestöpseltes externes Messgerät gemessen werden.

Mit externen Zusatzelementen können die h-Parameter usw. von Transistoren gemessen werden.

EE 32 761 *für weitere Einzelheiten*

TRANSISTOR-TESTER

Grundy & Partners Ltd, 3 The Causeway, Teddington, Middlesex

(Abbildung Seite 254)

Der Tester ist für Einsatz zusammen mit beliebigen Mehrbereich-Messgeräten konstruiert, die ein 1 mA- oder besseres Messwerk und vorzugsweise einen eingebauten Überlastungsschutz haben. Mittels der Befestigungsklemmen kann das Gerät direkt an ein Universal-Avo-Meter angebaut werden.

In die Transistor-Messungen einbegriffen sind die Kollektorrestströme mit Basis offen (I_{co}) und mit Emitter offen (I_{co}) bei 4,5 V Spannung.

Dioden werden in der Durchlassrichtung mit einem vom Durchlasswiderstand abhängigen Strom von bis zu 10 mA und der Sperrstrom bei 9 V Spannung geprüft.

An Transistoren mit Verlustleistung bis zu 800 mW kann eine brauchbare Messung des Stromverstärkungsfaktors β durchgeführt werden, und auch für höhere Verlustleistungen ist die Anzeige annehmbar.

Fünf umschaltbare Basiseingangsströme von 5, 10, 50, 100 und 500 μA stehen zur Verfügung. Die Kollektorspannung liegt mit 4,5 V fest.

Mit Hilfe der vorgesehenen zwei Klemmensätze ist es möglich, zwei ähnliche Transistoren oder Dioden in der geringsten Zeitspanne unter genau denselben Bedingungen zu vergleichen oder zu paaren.

Die eingebaute Batterie kann unter Belastung geprüft werden, wodurch durch Batterieausfall entstehende Fehler vermieden werden.

EE 32 762 *für weitere Einzelheiten*

FREISTEHENDE ZWERGLÖTFAHNE

Sealectro Corporation, Hersham Factory Estate, Lyon Road, Walton-on-Thames, Surrey

(Abbildung Seite 254)

Diese freistehende Zwerglötfahne hat einen Knopfzapfen mit Teflon-Körper für Eindrückmontage. Die Gesamtlänge des Bauelementes ist 7,5 mm; die Lötfahne ist 4 mm lang. Der durch das Chassis gehende Teflon-Körper hat einen Durchmesser von 3,8 mm und der Bund für Chassisauflage einen von 4,25 mm. Die Lötfahne besteht aus Messing. Lieferbar in allen Standardfarben für Schaltungskennzeichnung.

EE 32 763 *für weitere Einzelheiten*

DREHWÄHLER

Thorn Electrical Industries Ltd, Thorn House, Upper St. Martins Lane, London, W.C.2

(Abbildung Seite 255)

Dieser "Drei-in-Einem"-Drehwähler ist eine Kombination aus (1) einem Schneidenankerrelais, das Kontaktfedern betätigt, und einem über eine Ratschenschaltung getriebenen Schaltwerk, (2) einem Drehschalter mit Schaltklinkengetriebe, der aus vier Kontaktbahnen mit je 12 Ausgängen und gegabelten Federschleifern besteht sowie (3) einem schaltklinkengetriebenen Folgeschaltrelais mit zwei Nocken, die Doppelkontaktsätze der Nockenkonstruktion entsprechend öffnen und schliessen.

Die Drehwählerausgänge sind kreisförmig angeordnet und zwar in vier Kontaktbahnen mit je 12 Ausgängen. Jede Kontaktbahn besteht aus einem Quadranten des Kreises und hat einen Sammelkontakt, der bei Betätigung des Wählers durch den Schleifer der Reihe nach mit jedem der 12 isolierten Ausgänge verbunden wird. Die vier gegabelten Federschleifer sind aus Phosphorbronze hergestellt, und die Schleiferkontakte sind elektrisch voneinander isoliert. Die Ausgänge der Drehschalter-Kontaktbahn können bei ohmschem Abschluss und 50 V Gleichspannung im Dauerzustand mit 0.5 A und bei unterbrochenem Betrieb mit 0,1 A belastet werden.

Das klinkengetriebene Schaltwerk hat zwei kreisförmige Nocken, die auf einer gemeinsamen Welle, die die Drehwählerschleifer betätigt, Platz finden. Entsprechend der vorbestimmten Nockenform kann jede der Nocken bis zu fünf Kontaktfedern betätigen.

Ausserdem sind noch zwei Kontaktsätze vorgesehen, die bis zu je vier Kontaktfedern haben können und bei jedem Schritt des Drehwählers geöffnet und geschlossen werden. Alle Kontaktfedern sind als lange Blattfedern mit Versteifung ausgebildet, um lange Lebensdauer und fehlerfreien Betrieb zu gewährleisten.

Spulengleichspannungen sind 12, 24, 48 und 110 V. Zwei Standardspulentypen sind lieferbar: (1) eine schnelle, niederohmige Spule, die den Drehwähler bei 4 W Leistungsbedarf mit bis zu 40 Schritten pro Sekunde betreiben kann, und (2) eine empfindlichere, langsamere Spule, die den Drehwähler mit bis zu 20 Schritten pro Sekunde bei 2 W Leistungsbedarf schalten kann.

EE 32 764 *für weitere Einzelheiten*

STABILISIERTES NETZGERÄT

W. G. Pye & Co. Ltd., P.O. Box 60, Cambridge

(Abbildung Seite 255)

Dieses Mehrzweck-Netzgerät für Labors hat vier Hauptausgänge: eine stabilisierte Hochspannungsquelle, die bei einer Höchstbelastung von 250 mA stufenlos von −10...+500 V regelbar ist; eine stabilisierte 250 V Vorspannung und zwei 6,3 V 5 A Heizspannungen mit Mittelabgriff. Da alle diese Stromversorgungen erdfrei sind, kann eine beliebige oder jede der Klemmen geerdet und, soweit es sich um Wechselspannungen handelt, hintereinander oder parallel geschaltet werden. Spannungsregelung des 500 V—Ausgangs erfolgt durch einen Drehschalter mit 4 Positionen in Kombination mit einem Potentiometer; der Schalter wählt den Ausgangsspannungsbereich in Stufen von 125 V, und das Potentiometer gibt stufenlose Einstellung innerhalb des Bereiches mit ungefähr 10 V Überlappen an jeder Seite. Am unteren Ende des 125 V—Bereiches kann die Einregelung durch den Nullpunkt und bis zu 10 V negativ gehen.

Mit einem eingebauten Messgerät kann entweder die Spannung oder der Strom der Hochspannungsquelle abgelesen werden. Der Vollausschlag des Instrumentes wird entsprechend dem benutzten Ausgangsspannungsbereich automatisch auf 250 V oder 500 V umgestellt.

Für Stromanzeigen können wahlweise Empfindlichkeiten von 250 oder 50 mA benutzt werden.

Die Instrumentskala ist für alle Bereiche geeicht. Die Restwelligkeit der Hochspannungsquelle ist geringer als 3 mV und die Konstanthaltung besser als 0,1% Änderung der Ausgangsspannung für 10% Schwankung der Eingangsspannung. Der Innenwiderstand der Quelle von Gleichstrom bis 50 kHz ist 0,75Ω. Die Vorspannung liegt mit 250 V fest und erlaubt bis zu 30 mA Stromentnahme. Durch ein an die Klemmen geschaltetes Potentiometer kann jedoch eine einstellbare Vorspannung abgegriffen werden.

Unter den weiteren Konstruktionsmerkmalen ist noch vollständiger Schutz gegen Überlastung und Kurzschluss zu erwähnen.

EE 32 765 *für weitere Einzelheiten*

MONITOR FÜR KERNTECHNISCHE „HEISSE PUNKTE"

Avo Ltd, Avocet House, 92-96 Vauxhall Bridge Road, London, S.W.1

(Abbildung Seite 255)

Das Gerät wurde zur Messung "heisser Gammastrahlungspunkte" im Bereich von 0,05...100 r/h entwickelt und ist zur Feststellung heisser Punkte in örtlichem radioaktiven Material bestimmt, das während der Aufbereitung niedergeschlagen wurde.

Die Ionisationskammer kann auf eine beliebige Kombination von drei Verlängerungsstangen mit Schlossverbindung und einer flexiblen Verbindung montiert werden, so dass die Ionisationskammer bis zu 4 Meter vom Bedienungspersonal entfernt ist.

Die Ionisationskammer hat ein Volumen von 160 cm³ und besteht aus einem Aluminiumkäfig, der eine 0,0001 mm starke "Melinex"-Folie trägt.

Mittels einer in die Kammer eingebauten Strontium 90—Quelle und zweier Schalter am Anzeigegerät können während Benutzung in Gebieten intensiver Strahlung Tests ausgeführt werden.

EE 32 766 *für weitere Einzelheiten*

SPEKTROMETER

Fenlow Electronics Ltd, Springfield Lane, Weybridge, Surrey

(Abbildung Seite 255)

Das Gerät wurde für die Analyse aufgezeichneter Wellenformen der im Maschinenbau auftretenden Schwingungen, Beanspruchungen usw. entwickelt. Der überstrichene Frequenzbereich liegt zwischen 0,3...1050 Hz. Das Gerät ist tragbar, komplett und wird vom 200.., 240 V Netz gespeist. Die Aufgabe des Spektrometers ist Nachweis und Messung der in der Aufzeichnung verborgenen periodischen Vorgänge.

Das Gerät hat ein eingebautes Messinstrument, das die Leistung der regellosen Wellenformen im Durchlassband anzeigt, für das es eingestellt ist. Das Signal kann hinter dem Filter für Aufzeichnungszwecke abgegriffen werden.

Fünf vorgesehene Filter-Durchlassbreiten geben Bandbreiten zwischen 0,06 und 37,5 Hz. Die für die benutzte Bandbreite zur Verfügung stehenden Aufladezeiten liegen zwischen 1,5 und 150 s.

Das Gerät hat verschiedene neue Eigenschaften und gibt eine nützliche und genaue Analyse der Eingangsdaten. Es ist eher ein Gerät konstanter Bandbreite als konstanten Q's und benutzt ein Überlagerungssystem mit Ausgangs-Tiefpassfiltern und zwei Quadratur-Kanälen, um Mehrdeutigkeit durch Phasensynchronisierung fast periodischer Eingänge zu vermeiden. Genaue Thermoelemente mit quadratischer Charakteristik werden für die Leistungsmessung benutzt und speisen eine Aufladungsvorrichtung mit regelbaren Aufladezeiten.

Die Bedienungsknöpfe und das Ausgangsmessgerät sind zusammen mit Eingangs- und Ausgangsklemmen auf der geneigten Frontplatte angeordnet. Nach Entfernung eines Gerätedeckels werden Monitorklemmen zugänglich; da das Spektrometer sieben Operationsverstärker enthält, wird es auf diese Weise möglich, dieselben für andere Zwecke zu benutzen, wenn sie nicht für die Analyse benötigt werden. Sie können z.B. zur Nachbildung der Gleichungen mechanischer Systeme eingesetzt werden.

EE 32 767 *für weitere Einzelheiten*

EINSTECK-RELAIS

The Keyswitch Company, 2 Ironsgate Wharf Road, Praed Street, London W.2

(Abbildung Seite 256)

Das Einsteck-Relais P-32 Typ 3000 kann mit jedem Relais Typ 3000 nach Normen der Britischen Postbehörde geliefert werden, d.i. mit 2 bis 18 Kontaktfedern (1 Ruhe- und bis zu 6 Umschaltkontakte).

Kontakte können aus 2 × Silber (300 mA), 2 × Palladium oder 2 × Platin (1 A), Hochleistungsfeinsilber (2 A), Silber-Kadmiumoxyd oder Hartsilber (8 A) bestehen.

Stecker und Buchsen sind für 250 V Gleich- oder Wechselspannung ausgelegt. Kontakt zwischen Stift und Buchse ist zwangsläufig. Eine Feder hält das Relais in jeder Lage fest.

Das Relais wird mit durchsichtiger Haube oder Metallkappe und Buchse geliefert.

EE 32 768 *für weitere Einzelheiten*

SPERRELAIS

Electrical Remote Control Co. Ltd, Ekremco Works, Bush Fair, Harlow, Essex

(Abbildung Seite 256)

Die Bestückung des Sperrelais Type UNIV/LA besteht aus max. acht Kontaktsätzen für Arbeits-, Ruhe-, Umschaltkontakte oder gemischte Anordnungen. Nach Anlegung eines kurzen Impulses an die Spule hält eine einfache Verriegelungsvorrichtung das Relais in der erregten Position. Nach Betätigung eines angebauten Hebels werden die Kontakte ausgelöst und gehen in die Ausgangsstellung zurück, bis ein weiterer Impuls durch die Spule geht.

Das abgebildete Sperrelais UNIV/LA/S ist dem Modell mit Handrückstellung ähnlich, kann aber durch elektrische Impulse sowohl verriegelt als auch ausgelöst werden. Es ist mit einer stabilen Platte ausgerüstet, die auch als Befestigungsplatte dienen kann. Auf dieser Platte ist eine kleine Magnetspule aufgebaut, die bei Erregung die Verriegelung auslöst.

Spulen sind für Wechselspannungen bis zu 440 V oder Gleichspannungen bis zu 230 V lieferbar. Die Kontakte sind für 6 A 230 V oder 2 A 440 V Wechselstrom oder 1 A 240 V Gleichstrom ausgelegt.

EE 32 769 *für weitere Einzelheiten*

ULTRASCHALL-DICKENMESSER

Vertrieb: Aveley Electric Ltd, Ayron Road, Aveley Industrial Estate, South Ockendon, Essex

(Abbildung Seite 256)

Das Kretz Ultraschall-Dickenmessgerät 6000 hat einen eingebauten hoch-

stabilen Breitbandverstärker für 3...20 MHz und wurde besonders dahingehend entwickelt, auch genaue Messung von Ausdehnung und Zusammenziehung zu ermöglichen; eine neue Trigger-Schaltung gibt eine Warnung, wenn eine vorgegebene Messgrenze erreicht wird.

Genaue Dickenmessungen werden durch Überbrückung mehrerer Impulse mit einem beweglichen Sockel erreicht, dessen Vorderkante so verschoben werden kann, dass er die erste Schwingung jedes reflektierten Impulses abteilt. Je grösser die Anzahl der für die Messung benutzten Echoimpulse ist, desto besser wird die Unterscheidung. Die vertikale Ablenkcharakteristik der Spur ist besser als 0,05 μs, so dass eine Echozeitunterscheidung von 0,0125 μs erzielt wird.

Für Risseprüfung liegt der wirksame Tiefenbereich zwischen 1 und 70 cm, und die obere Grenze für Dickenmessungen liegt bei 20 mm, ist jedoch von der Frequenz und Werkstoffdämpfung abhängig. Der Leistungsbedarf ist 180 VA. Niederspannungsbuchsen sind für Arbeiten vorgesehen, für die strenge elektrische Schutzmassnahmen erforderlich sind. Bei Benutzung dieser Buchsen wird die Hochspannungsverbindung automatisch abgeschaltet.

EE 32 770 *für weitere Einzelheiten*

RECHTECKWELLENGERÄT

Feedback Ltd, Crowborough, Sussex

(Abbildung Seite 256)

Das von Feedback Ltd, einer Schwesterfirma der Servomex Controls Ltd, hergestellte Rechteckwellengerät SW98 erzeugt ein Rechteckwellen-Treibsignal für sich wiederholende Analoge. Eine Rechteckwelle der Netzfrequenz wird abgegeben, das Gerät erzeugt aber auch Rechteckwellen von extern angelegten Sinuswellen im Frequenzbereich 50 Hz... 10 kHz. Die Anstiegszeit für jede beliebige Frequenz ist ungefähr 2 μs, und das genaue 1:1 Verhältnis kann mittels eines vorgesehenen Tastverhältnistrimmers eingestellt werden.

Für zufriedenstellenden Betrieb ist ein Signal von mindestens 2 V Scheitelspannung erforderlich; die Ausgangsspannung kann unabhängig von der Eingangsamplitude stufenlos von 0...50 V doppelter Spitzenspannung eingestellt werden.

Für Verwendung mit sich wiederholenden Analogen ist ein Schwingkreis zur Erzeugung geeichter Schwingungen eingebaut, die der Zeitmessung von Oszillografspuren dienen. Die Eichfrequenz ist 2,5 kHz, und die Schwingungsreihe kann durch Umschaltung entweder in der positiven oder negativen Hälfte der Rechteckwelle auftreten.

EE 32 771 *für weitere Einzelheiten*

INDUSTRIELLE MESSGERÄTE

Ekco Electronics Ltd, Southend-on-Sea, Essex

Im Ekco-Fertigungsprogramm stehen besonders für die industrielle Verfahrenstechnik drei neue Geräte zur Verfügung. Der Feuchtigkeitsmesser Type N 680 wurde in erster Linie für Papiermaschinen entwickelt und gibt über den Bereich von 2...75% eine genaue Anzeige des Feuchtigkeitsgehaltes des Papiers. Andere Ausführungen sind mit beschränkten Messbereichen wie z.B. 2...15% und 60...75% lieferbar. Das Gerät kann am trockenen Ende der Maschine als Feuchtigkeitsmonitor oder zusammen mit dem Ekco-Substanzmesser am feuchten Ende eingesetzt werden. Die letztere Kombination ermöglicht Messen des Trockensubstanzgewichtes in einer Position, in der diese Messung früher unmöglich war.

Das Speichergerät Type N 682 wurde besonders für Beschichtungsverfahren entwickelt; es speichert eine Messgerätanzeige für eine vorgewählte Zeitdauer, die mit dem Herstellungsverfahren in Beziehung steht und mit der Maschinengeschwindigkeit synchronisiert wird. Dadurch wird es möglich, ein Messresultat des Ausgangsmaterials mit der Anzeige eines weiteren Messgerätes für das überzogene Material zu vergleichen. Durch die Verzögerungszeit des Speichergerätes können Messungen des überzogenen und des unüberzogenen Materials für dieselbe Fläche nach dem Trocknen oder Aushärten verglichen werden. Die Differenzsignale können dann einem automatischen Regler zugeführt werden, der die Motoren betätigt, die die Eintauchwalze oder den Rakel positionieren. Eine Direktanzeige des Beschichtungsgewichtes kann auch an einem Messgerät angezeigt oder auf einem Schreiber registriert werden.

Laufendes und genaues Messen von in Bandform hergestellten Metallen bis zu 12.7 mm Stärke kann mit dem Sekundär-Röntgenstrahlmesser Type N 658 ausgeführt werden. Die Röntgenstrahlen werden als Bremsstrahlung einer Strontium 90-Quelle erzeugt. Durch den eingebauten Selbstregler Type 604 ist automatische Fertigungsregelung gegeben.

EE 32 772 *für weitere Einzelheiten*

ELEKTRONISCHE MIKRO-SCHALTER

Servo Consultants Ltd, 10 Bouverie Place, London, W.2

(Abbildung Seite 257)

Der Bedarf für einen robusten und kontaktlosen Baustein für die Synchronisierung automatischer Maschinen führte zur Entwicklung dieses Gerätes, das hauptsächlich für Verwendung anstelle von Kontaktpaaren bestimmt ist, die durch den Nocken einer Maschine betätigt werden. Der Nocken-Abtastkopf enthält keine beweglichen Teile, und somit ist die Wahrscheinlichkeit einer langen Lebensdauer äusserst hoch. Alle elektronischen Bauelemente sind reichlich bemessen, und der ganze Baustein ist so durchkonstruiert, dass er die in vielen industriellen Verwendungen auftretenden übermässigen Erschütterungen aushalten kann.

Betätigung des Gerätes erfolgt durch sich bewegende Nocken, Zahnstangen oder ähnliche Bauteile, solange dieselben aus magnetischen Werkstoffen hergestellt sind. Der normale Abstand zwischen dem Vorderende des Bausteins und dem Nocken kann für den "Einschalt"-Zustand zwischen 0 und 0,75 mm schwanken, muss für den "Ausschalt"-Zustand aber grösser als 0,63 mm sein. Die "Einschalt"- und "Ausschalt"-Zustände werden ganz willkürlich gewählt, und der Baustein kann für unbegrenzte Zeit in jedem der beiden Zustände verbleiben. Der Ansprechbereich überstreicht daher Gleichstrombetrieb bis zu 1000 UPM. Die Auflösungsgenauigkeit ist ±0.5 mm und entspricht bei einem Nocken mit 6" (153 mm) Durchmesser einer Winkelgenauigkeit von ungefähr 25 Bogenminuten.

EE 32 773 *für weitere Einzelheiten*

MILLIMETER-KLYSTRONS

Elliott Brothers (London) Ltd, 34 Portland Place, London, W.1

Elliott Brothers hat vier neue Klystronoszillatoren für die 4 mm, 6 mm und 12 mm Bänder entwickelt.

Diese Klystrons haben Wasserkühlung und sind nach dem freischwebenden Triftröhrenprinzip konstruiert. Ihre Ausgangssignale sind aussergewöhnlich frei von Wärmedrift und magnetischer Rücktrift. Das in der Konstruktion verwandte Glas hat einen hohen Erweichungspunkt und ist mit Molybdänabschluss versehen. Die Röhren können demzufolge während des Herstellungsverfahrens auf Temperaturen von 700°C erwärmt werden, wodurch hohes Vakuum, gute geräuscharme Kennwerte und verbesserte Kathodenlebensdauer erzielt werden. Eine durchschnittliche Lebensdauer von mindestens 500 Stunden ist wahrscheinlich.

Type 4FK1 enthält viele im 15 W-Q-Band-Klystron 8FK1 verwendete Bauelemente und kann bei einer auf ungefähr 75 GHz festgelegten Frequenz eine Ausgangsleistung von über 100 mW abgeben.

Für das 6 mm Band sind jetzt zwei Klystrons in Produktion. Type 6FK1 ist ein Festfrequenz-Oszillator, der bei 50 GHz eine Ausgangsleistung von ungefähr 2 W abgibt; Type 6TFK2 ist eine durchstimmbare Ausführung des 6FK1.

Type 12TFK2, ein neuer 12 mm—Oszillator, ist eine durchstimmbare Ausführung des 10 W—Festfrequenz-Oszillators 12KF1 und hat eine Ausgangslei-

stung von mindestens 8 W über einen 100 MHz Bereich, dessen Mittelfrequenz im 21...25 GHz Band liegt.

EE 32 774 *für weitere Einzelheiten*

SI-GLEICHRICHTER

International Rectifier Co. (Great Britain) Ltd, Hurst Green, Oxted, Surrey

(Abbildung Seite 257)

Eine Reihe neuer Silizium-Gleichrichtersätze mittlerer Leistung wird von der International Rectifier Co. (G.B.) Ltd. angeboten. Die Gleichrichtersätze sind so bemessen, dass die gängigsten Stromversorgungsbedürfnisse von Geräten wie Leistungsverstärker, Rundfunksendegeräte und Rechnernetzgeräte usw. gedeckt werden.

Gleichrichtersätze sind für einphasige Einweg-, einphasige Brücken- und Drehstrom-Brückenschaltung lieferbar. Die Sätze haben einen Wirkungsgrad bis zu 98%, wodurch die durch Erwärmung auftretenden Probleme wesentlich verringert werden. Die hohe Ausgangsleistung im Verhältnis zur Grösse erleichtert das Auswechseln in existierenden Geräten und verringert den Raumbedarf in Neukonstruktionen auf ein Minimum. Alle Sätze sind robust konstruiert, die Platten und Klemmen gegen Verdrehung gesichert; die Montageschlitze haben offene Enden und die Klemmen Farbkennzeichnung.

EE 32 775 *für weitere Einzelheiten*

HF-LEISTUNGSRÖHREN

Associated Electrical Industries Ltd, 155 Charing Cross Road, London, W.C.2

(Abbildung Seite 257)

Eine neue Kühlmethode wurde für drei neue wassergekühlte Ediswan HF-Leistungsröhren vorgesehen, für die höhere Wirksamkeit, niedrigere Installationskosten für die Röhreninstallation und einfachere Wartung in Anspruch genommen werden. Statt des üblichen Kühlmantels wird eine Kupferrohrspirale für Wasser direkt an die Anode angebracht. Es handelt sich um die Röhrentype 15P12 mit 0,6 kW maximaler Anodenverlustleistung und 2,5 kW HF-Höchstausgangsleistung sowie die Röhrentypen 16P12 und 16P13, deren maximale Anodenverlustleistung 3 kW und HF-Höchstausgangsleistung 7,5 kW ist.

Da keine Abdichtungen vorhanden sind, wird das Leckagerisiko herabgesetzt. In jedem Fall ist die Konstruktion kompakter als die vergleichbaren Typen mit herkömmlicher Kühlung. Der Wasserbedarf ist gering und liegt für 3 kW Verlustleistung ungefähr bei 1 Liter. Eine patentierte Ediswan-Schutzvorrichtung gegen übermässige Anodenverlustleistung ist eingebaut.

Die angefügten Suffixe 12 und 13 bezeichnen die vorgesehene Wasseranschlussmethode: 16P12 wird z.B. mit Schlauch und 16P13 mit Verschraubungen angeschlossen.

Die 15P12 hat ein aus einem neuen nichtemittierenden Werkstoff konstruiertes Gitter, das eine viel höhere Gitterverlustleistung zulässt.

EE 32 776 *für weitere Einzelheiten*

Zusammenfassung der wichtigsten Beiträge

Ein Analogrechner für Antennenstrahlungsdiagramme von H. Page, G. J. Phillips und J. A. S. Fox

Zusammenfassung des Beitrages auf Seite 206-212

Zur Berechnung der horizontalen Strahlungscharakteristik aus mehreren Strahlungselementen bestehender und auf einem zentralen Mast angeordneter Antennen wurde ein Analogrechner entwickelt. Das Strahlungsdiagramm eines Einzelelementes muss bekannt sein und dient als Grundlage der Berechnung des Diagrammes für eine Anzahl um den Mast verteilter identischer Elemente. Die Ströme in den Elementen können jede gewünschte Amplitude und Phase haben.

In dem angewandten Verfahren werden NF-Spannungen addiert, wobei jede Komponente die Strahlung von einem Element in einer bestimmten Richtung darstellt. Bei Verwendung einer Stufenschalterbank können die entsprechenden Summierungen nacheinander für Richtungswinkel mit 7,5° oder 15° Abstand durchgeführt und die Resultate auf einem Messgerät angezeigt werden. Der Rechner kann auch anderen Sichtanzeigen angepasst werden.

Ein schneller Gleichstrom-Wechselstrom-Stellantrieb von B. A. Unvala und B. T. Denvir

Zusammenfassung des Beitrages auf Seite 213-217

Das beschriebene Servogerät wurde zum Antrieb eines 10 W-Wechselstrom-Stellmotors benötigt, der mit kleinen Eingangsspannungen über den Frequenzbereich von Gleichstrom bis zu 70 Hz arbeitet. Die Schaltung besteht aus einem bei 400 Hz geschalteten Diodenringmodulator und nachfolgendem

Wechselstromverstärker mit Phasenverschiebung und Begrenzernetzwerk. Im Modulator werden Si-Gleichrichter und im volltransistorisierten Verstärker durchweg Si-Transistoren benutzt. Die Stromversorgung wird auch beschrieben.

FM-Fernübertragung im kreisrunden Hohlrohr von R. Hamer

Die Durchführung von Fernübertragungen in kreisrunden Hohlrohren (H_{01}-Welle) bei Benutzung von Frequenzmodulation wird unter der Voraussetzung untersucht, dass eine besondere Hohlrohrstruktur zur Verfügung steht und dass Unvollkommenheiten des Hohlrohrs regellos auftreten. Die in Betracht gezogenen grundsätzlichen Beschränkungen sind: (a) die durch Wellentypumsetzung an den Mangelstellen des Hohlrohrs ansteigende Dämpfung der H_{01}-Welle, (b) die sich aus Parallelfluss und Echosignalen ergebende Intermodulations-Verzerrung, (c) Zerstreuung im Hohlrohr.

Zusammenfassung des Beitrages auf Seite 218-225

Die Untersuchung berücksichtigt besonders Mehrkanal-Fernsprechübertragungen, da diese die grössten Schwierigkeiten bieten; das Modulationssignal wird durch regelloses Geräusch nachgebildet.

Die Untersuchungsergebnisse werden für einen hypothetischen Weg angewandt, der aus regellos zusammengesetzten Kupferrohrabschnitten von 2 Zoll (50,8 mm) Durchmesser besteht und mit einem Verluste aufweisenden Dielektrikum ausgekleidet ist. Das entstehende Intermodulationsrauschen in einem Fernsprechkanal eines 2700-Kanal-Systems mit einer Trägerfrequenz von 35 GHz wird von einer Reihe von Parametern abgeleitet.

Abschliessend wird festgestellt, dass die untersuchten Beschränkungen die Verwendung von Frequenzmodulation für die Fernübertragung in kreisrunden Hohlrohren nicht ausschliessen.

Gleichstromumformer: Ausführungswahl und Berechnung von J. S. Bell und P. G. Wright

Zusammenfassung des Beitrages auf Seite 226-231

Die Berechnung von Gleichstromumformern mit ein und zwei Transformatoren wird besprochen und ihre Leistung verglichen. Die Berechnungsmethode ist angegeben, und zwei praktische Beispiele werden durchgerechnet.

Linear-logarithmischer Wandler für lineare Mittelwertzähler von J. Turnbull und D. N. Walder

Zusammenfassung des Beitrages auf Seite 238-239

Der beschriebene Wandler wird von einer Untersetzerstufe mit einem Verhältnis von 2:1 gespeist, die negativgehende Rechteckwellen mit 30 V Amplitude erzeugen kann, und gibt über zwei Dekaden einen ungefähr logarithmischen Ausgang ab. Für das Ausgangsmessgerät kann durch Umschaltung Vollausschlag über einen Zählbereich von 10 . . . 100 oder 100 . . . 1000 gewählt werden.

Genaue Frequenzregelung eines Drehumformers von M. J. Tucker

Zusammenfassung des Beitrages auf Seite 240-241

Das Königliche Forschungsschiff "Discovery II" wurde mit einer 50 Hz—Stromquelle ausgerüstet, deren Frequenzgenauigkeit ungefähr $1 \cdot 10^{-5}$ beträgt. Ein kleiner Drehumformer ist phasenstarr mit einem von einem Quarzoszillator abgegebenen 50 Hz—Bezugssignal angeordnet.

Ein neuer Gleichstrompegelregler für anpassungsfähige Systeme von R. A. Johnson und J. D. Hill

Zusammenfassung des Beitrages auf Seite 242-244

Eine neuartige elektronische Schaltung, die den Spannungsabfall in einem Verbraucher innerhalb eines Bruchteils eines Prozentes konstant hält, während der Gleichstrompegel des Verbrauchers innerhalb eines grossen Bereiches geändert werden kann, wird beschrieben und analysiert. Für die Schaltung werden nur elektronische Bauelemente mit Standardtoleranzen benutzt, und die grosse Genauigkeit wird durch Fehlerkompensationstechnik erzielt.

In einer beispielsweise dargestellten Konstruktion kann eine 20 kΩ Last um über 200 V verschoben werden, während ihr Spannungsabfall innerhalb ±0,2% konstant bleibt.

EE 32 124 *for further details*

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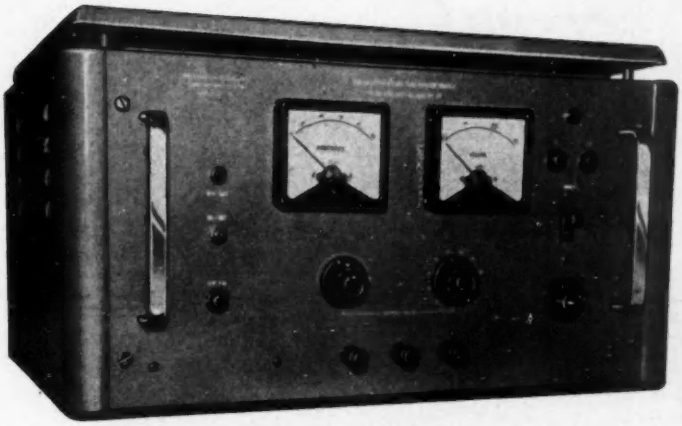

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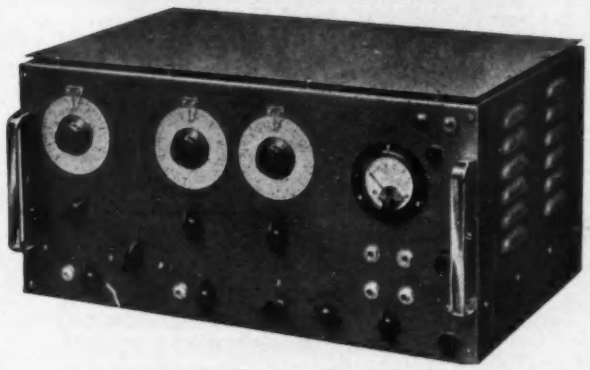

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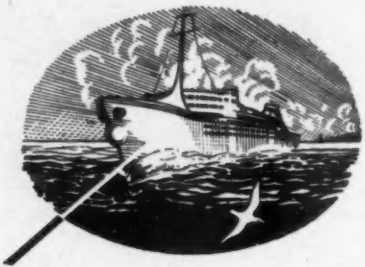

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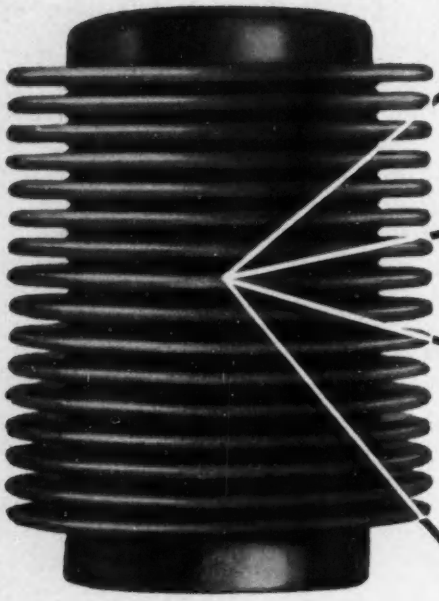

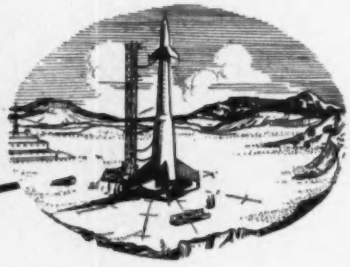

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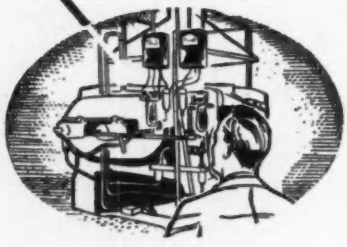

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All Elesta Tubes have pure molybdenum cathodes which alone ensure very precise and constant characteristics over a practically unlimited operating life for most applications.

Write or telephone to-day for practical and proven circuits and technical information about Elesta cold cathode tubes.

HIGH-SPEED MINIATURE DECADE COUNTER & SELECTOR

EZ.10B

Max. Counting Rate	1 million p.p.s.
Anode Supply Voltage	580 V
Anode Sustaining Voltage	300 V
Anode Current	1.5mA
Pulse Drive Peak Amplitude	−100 to −150 V
Output Pulse Amplitude	7 V
Cathode Resistors	6.8 k-Ohms

48 mm × 21 mm ϕ

BRITEC LIMITED
17 CHARING CROSS ROAD, LONDON, W.C.2
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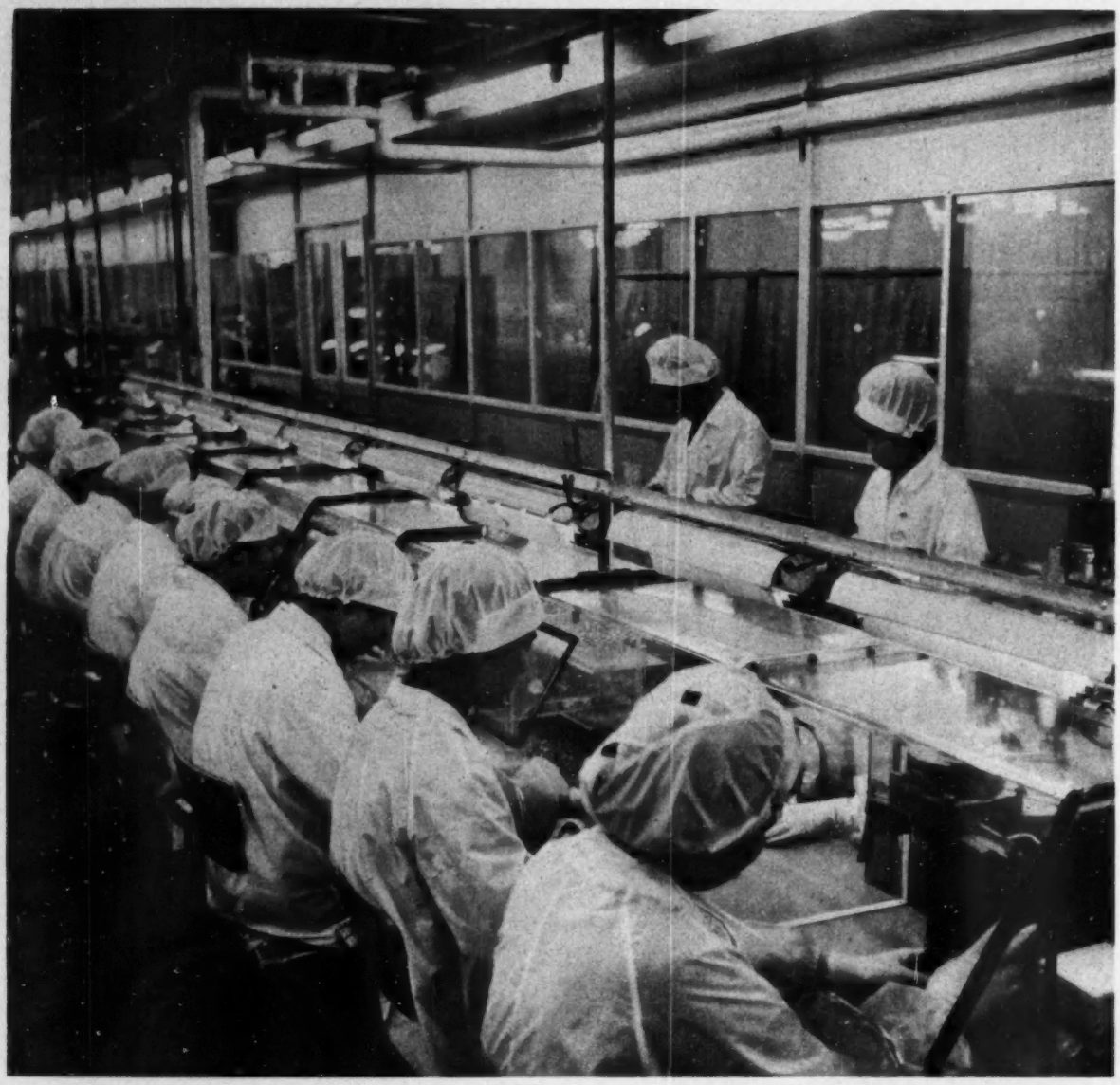
EE 32 12B *for further details*



An NEC semiconductor device for every circuit application

The range of semiconductor products at NEC is perhaps the widest of any manufacturer. Entertainment or industrial, standard broadcast frequencies to microwave — NEC has a semiconductor device with the ratings and characteristics for your application. There's a wide selection of current ratings, operating temperatures, and mountings.

These are produced in NEC's new semiconductor plant where crystal surfaces are cleaned by 100 tons of hyper pure water daily. Every seal is tested in krypton isotopes, providing a failure rate suitable for the most critical applications.

A single source for semiconductors can mean a saving in time and costs. Just let NEC know your requirements and full technical data will be sent.

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•PNP super-grown Germanium transistors •Germanium photo transistors •PNP alloy junction Germanium transistors •Silicon Mesa transistors •Germanium Mesa transistors •Germanium gold-bonded diodes •Silicon rectifiers •Silicon controlled rectifiers •Silicon capacitors •Zener diodes •Germanium point-contact mini-diodes •Silver-bonded diodes •Microwave mixer diodes • Silicon junction mini-diodes

Reliability The first NEC transistorized carrier telephone system was an NT & T installation in 1958 between Toyama and Takaoka, a distance of 15 miles. It consists of two terminal stations and a repeater station with 240 channels using 1,6000 transistors.

During last 14,000 hours of operation transistor failure has caused only two channel faults. This corresponds to a failure rate of 0.009% per 1,000 hours.

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LOW COST
WIDE VERSATILITY

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Size
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EXTREME SENSITIVITY	**accurate down to 100μV**
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AMPLIFIER RANGE	**10c/s to 10Mc/s**
AMPLIFIER GAIN	**60dB in 10dB steps**
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nett price in U.K. **£55**

including very low capacity screened leads and probe

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IT/Ea.

The Highest Sensitivity
and the lowest noise.....

Advanced electronic research by Hitachi technicians has now resulted in the development of a superb frame grid type twin triode (6R-HH8) with excellent high gain and low noise characteristics. As a component of the tuner, the 6R-HH8 ensures an excellent picture with a remarkable degree of definition.

fig. 1 Gain characteristics

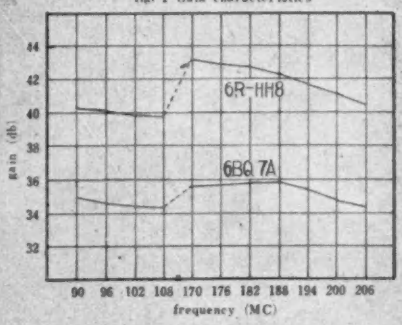
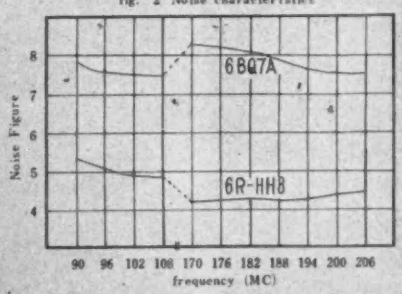
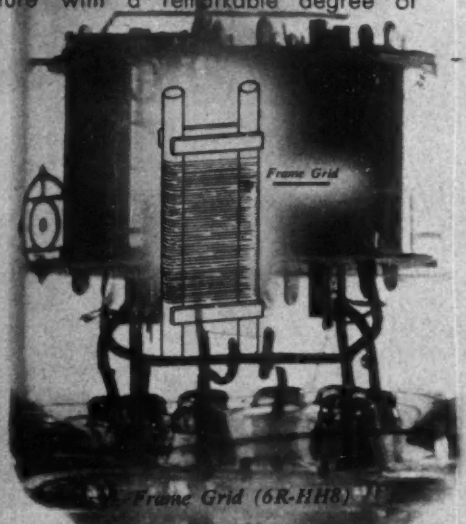


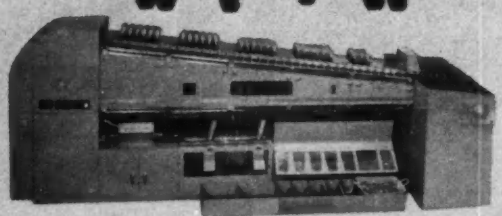
fig. 2 Noise characteristics





Frame Grid (6R-HH8)

Hitachi also produces other receiving tubes and components for television which, when used together with the new 6R-HH8, cannot fail to earn any maker a market reputation even better than he currently enjoys.



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Tokyo Japan
Cable Address: "HITACHY" TOKYO

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with glove box for semiconductor devices

We design and manufacture Ovens to Customer's special requirements. Should you have any problems in this field our Technical Department is always willing to help you solve them. Vacuum Ovens with temperatures of up to 600°C are also manufactured by us on similar lines but with Sectional Heating and Water-Cooled Ends.

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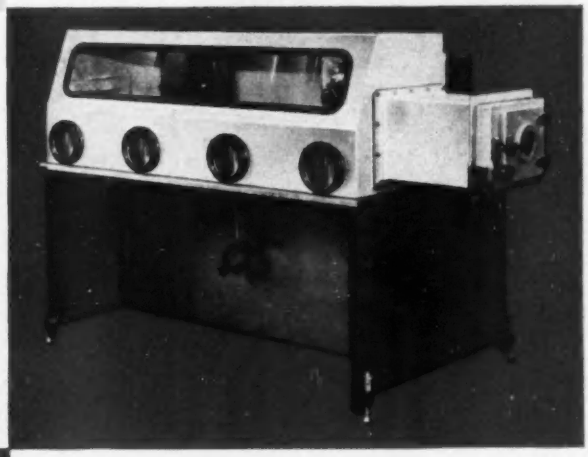

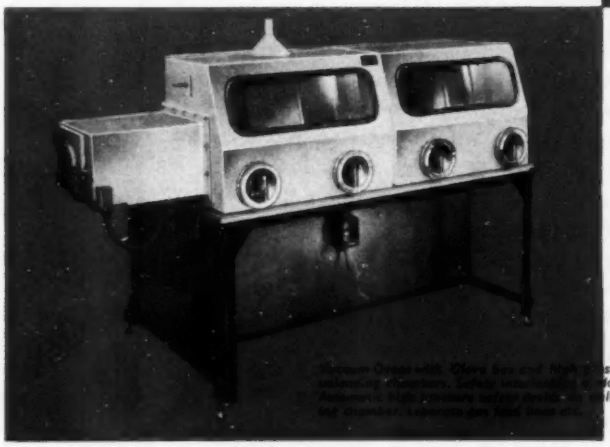

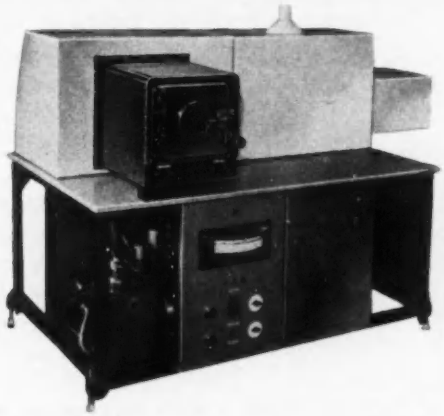

Made throughout in polished stainless steel.
Single action door openings.
Rectangular with self spacings to suit.
Double-ended controls.
Electrical interlocking of air inlet and isolation valve.
Outer cover hermetically sealed.
Temperature Range 0-400 C.
or equivalent F.

Temperature Control: Normal ±7½°C. Special ±1°C.
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(can be altered to special requirements).
Vacuum Range: To 10^{-5} m.m.
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NEW MULLARD TRANSMITTING VALVES

MULLARD introduce seven additions to their extensive range of transmitting valves. These new developments, for use in television transmission, mobile radio communications and microwave links, combine the advantages of the latest manufacturing techniques together with long-term experience gained in operational service.

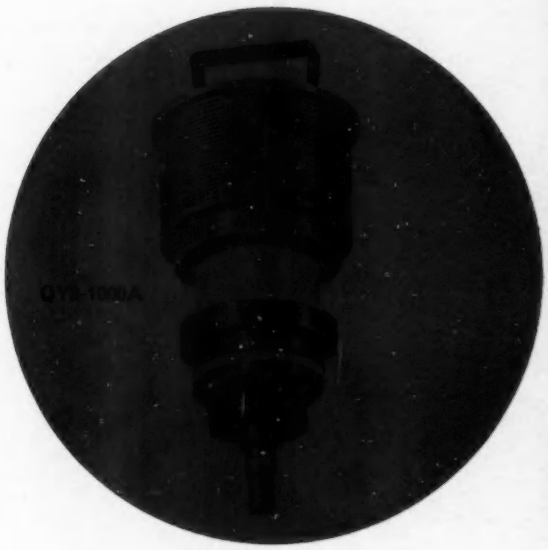
TELEVISION TRANSMISSION

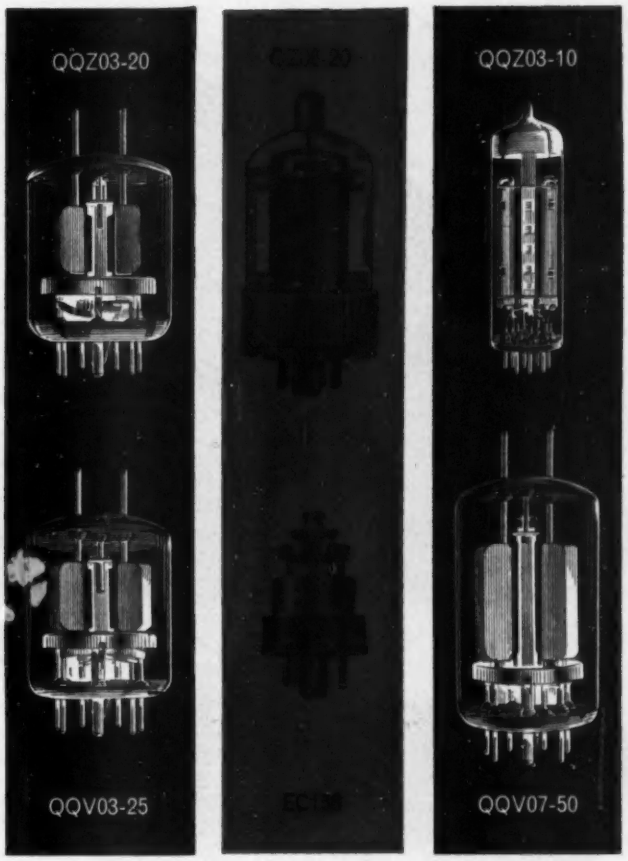
Coaxial u.h.f. power tetrode QY3-1000A, with ceramic construction, for use as a Class B or Class C amplifier at frequencies up to 1Gc/s. As an amplifier for television service the QY3-1000A will provide an output power of 1.28kW at a frequency of 900 Mc/s and 1.76kW at 600Mc/s.

MOBILE RADIO

Three new quick heating versions of existing tetrode transmitting valves. The use of these valves, the QQZ03-10, QQZ03-20, and the QZ06-20 will permit considerable economy in transmitter standby power consumption and will also effect a reduction of chassis ambient temperature. All three valves deliver more than 70% of maximum output power within one second of switching on.

	Power output at full ratings.		Max. operating frequency
	(W)	(Mc/s)	(Mc/s)
QQZ03-10	13	200	225
QQZ03-20	45	200	500
QZ06-20	70	60	175





COMMUNICATIONS

Two new double tetrodes **QQV07-50** and **QQV03-25** meet the demand for increased anode dissipation and can be incorporated in equipments requiring output powers of 70W and 35W respectively, including equipment where the **QQV03-20A** and **QQV06-40A** are being used.

MICROWAVE LINKS

EC158 disc seal s.h.f. triode for microwave link communication equipment capable of 5W output power at 4Gc/s (50 Mc/s bandwidth at −0.1dB). The unique performance of this most advanced valve is made possible by the incorporation of a special dispenser cathode.

FURTHER INFORMATION

Further information on all these devices is available, please quote reference **D4134** when writing to Mullard House.

Mullard

GOVERNMENT AND
INDUSTRIAL VALVE DIVISION

Mullard

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Emitape THE TAPE USED FOR THE 'MASTERS' OF MOST RECORDS

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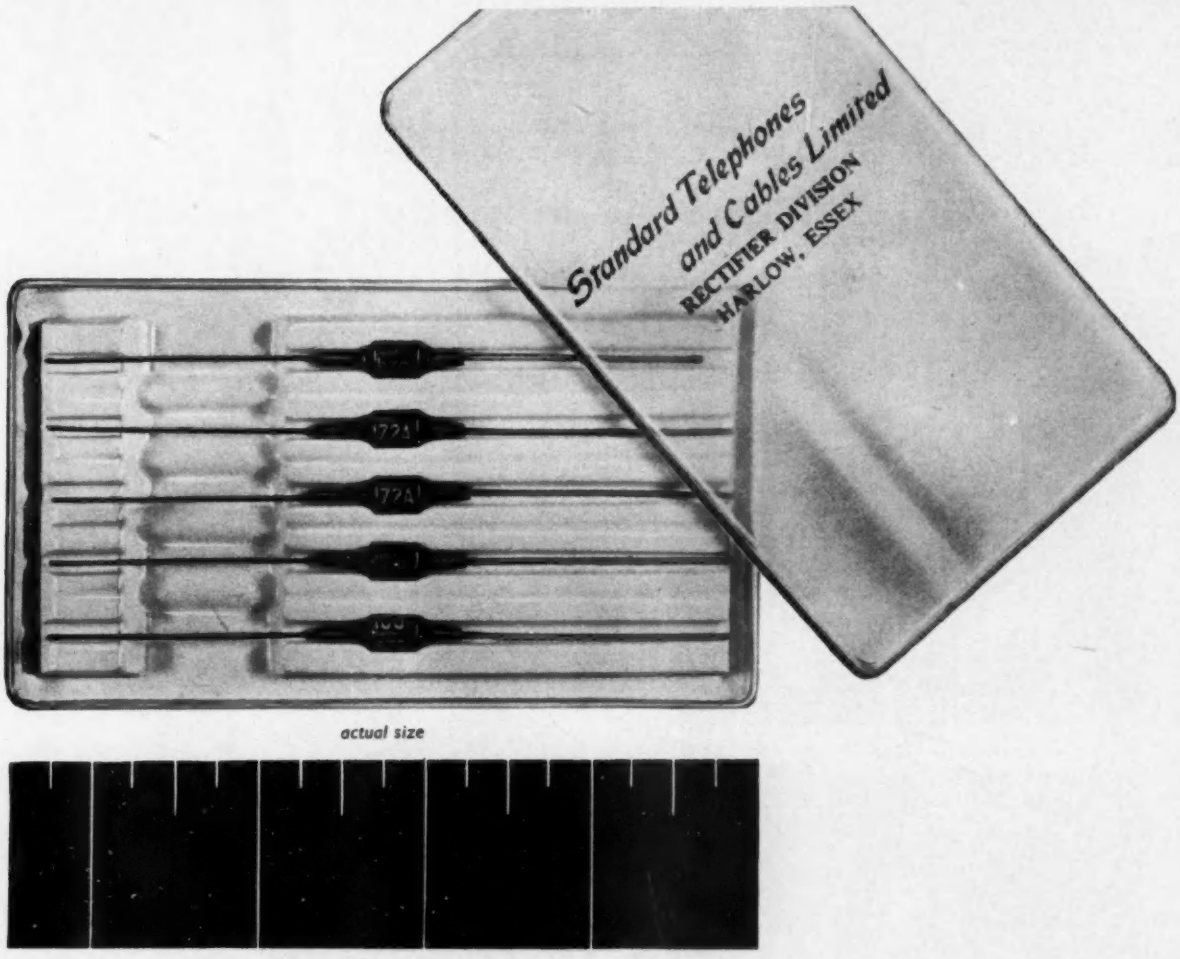
EMITAPE DIVISION, E.M.I. Sales & Service Ltd., Hayes, Middlesex.



actual size

SenTerCel 1 WATT SILICON ZENER DIODES

- *Have a large dissipation for their size*
- *Are suitable for high temperature operation*
- *Have a low temperature co-efficient of voltage*
- *Are suitable for use as regulators, limiters, surge suppressors, and voltage references*
- *The first complete range of close-tolerance ZENER Diodes available from production*

Characteristics and ratings of SenTerCel Zener Diodes are given in publication MF/103

Z2 SERIES ZENER DIODES		
±5% Voltage Tolerance (Red and Green Sleeves)	TYPE	NOMINAL VOLTAGE
	Z2A33F	3.3
	Z2A36F	3.6
	Z2A39F	3.9
	Z2A43F	4.3
±10% Voltage Tolerance (Red and Yellow Sleeves)	Z2A47F	4.7
	Z2A51F	5.1
	Z2A56F	5.6
	Z2A62F	6.2
	Z2A68F	6.8
	Z2A75F	7.5
	Z2A82F	8.2
	Z2A91F	9.1
±20% Voltage Tolerance (Red and Blue Sleeves)	Z2A100F	10
	Z2A110F	11
	Z2A120F	12
	Z2A130F	13
	Z2A150F	15

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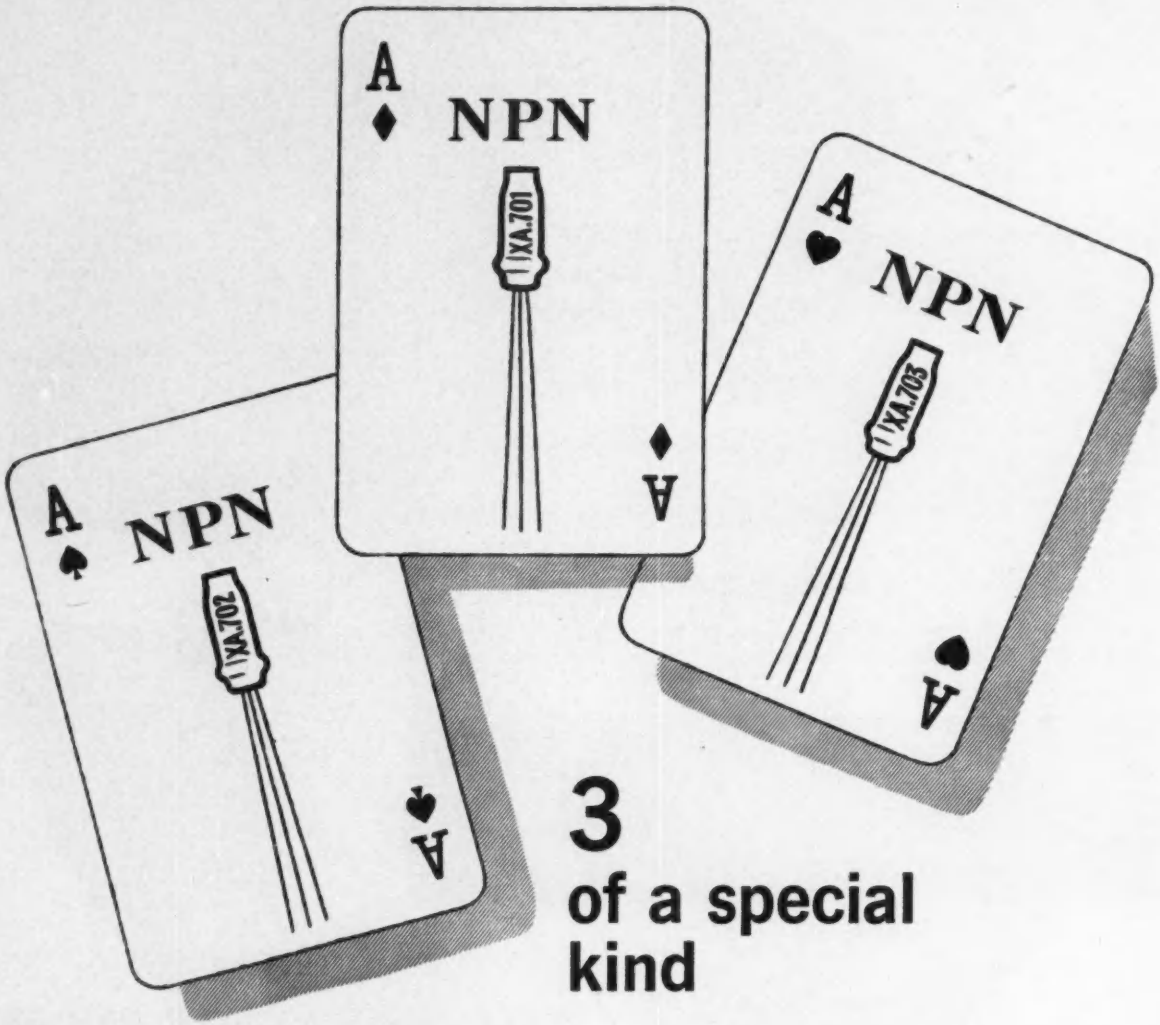

3 of a special kind

We make three germanium NPN alloy high speed switching transistors, each one an ace in its own class, and if you don't think that's something to write home about, just look at these brief specifications:

	Maximum V_{cb} (Volts)	Maximum V_{ceo} (Volts)	Maximum I_c (mA)	Minimum f_α (Mc/s)
XA701	25	15	200	3
XA702	25	15	400	5
XA703	25	12	400	10

But before you tell the folks back home about them,
why not drop us a line first and get the whole story? Go on. Ask.

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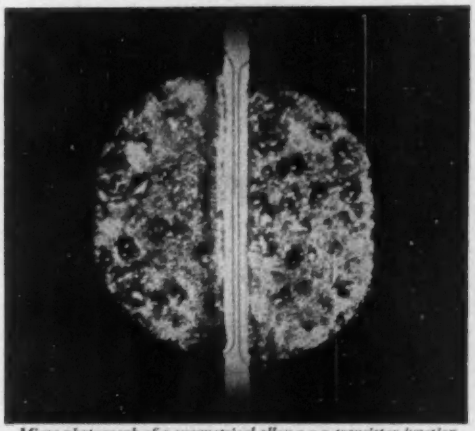
No. 2 IN THE SERIES

Technical Information for the Transistor Circuit Designer

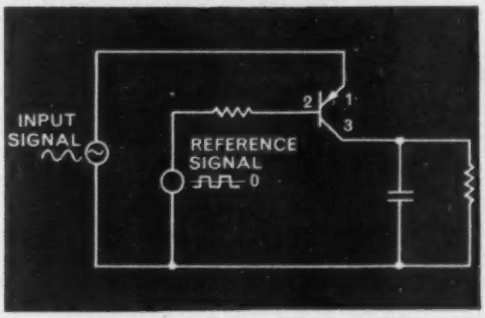


Micro photograph of a symmetrical alloy p n p transistor junction, (indium emitter and collector on germanium wafer base).

Bidirectional Switching Transistors

A bidirectional transistor has equal collector and emitter areas so that in a p n p structure it is immaterial which of the two p regions is used as the emitter and which as the collector. The transistor will give an appreciable, but not identical, gain in both directions and for most circuits it is sufficient that the gain shall be above a certain minimum in either direction. For convenience, one terminal of the transistor is assigned to the collector and the gain is termed "normal gain" when this terminal is connected into the collector circuit. With this terminal connected into the emitter circuit, the gain of the transistor is then termed "inverse gain".

Bidirectional transistors behave as efficient electronic switches capable of switching signals having a polarity which is either positive or negative with respect to the base or reference terminal. A typical example is the phase sensitive demodulator shown here. The reference phase signal is applied to the base of the transistor and terminal 1 acts as an emitter or collector according to whether the polarity of the input signal is positive or negative when the reference signal is negative.



Other examples of the use of bidirectional transistors are to be found in modulators, computer read and write circuits, analogue computer switching circuits, time division multiplex, voltage comparator circuits for analogue to digital conversion and various types of sequential switching circuits.

(T_{amb} = 25°C unless otherwise stated)

Type	Description and Applications	h_{fe} measured at			V_C	I_C	f_{hb} Typ.	V_{CB} Max.	V_{CE} Max.	$T_{junc.}$ Max.	$P_{C\,max}$ at 25°C
		Min.	Typ.	Max.	(V)	(mA)	Mc/s	(V)	(V)	(°C)	(mW)
	Germanium Alloy Junction Transistors										
TK20C	Bidirectional p-n-p. Excellent switching performance at relatively high collector currents. Very low saturation resistance.	15	35	*95	−0·15	−100	6·0	−30	−12	75	200
		†15	35	*95	−0·15	−100					
TK25C	Similar to the TK20C, but with a cut-off frequency greater than 8 Mc/s.	*30	50	*125	−0·15	−100	11	−20	−6	75	200
		†*30	50	*125	−0·15	−100					

†Inverse characteristics *95% limit.

STC Application Report, "Bidirectional Transistors" will be gladly sent on request; ask for MK/139

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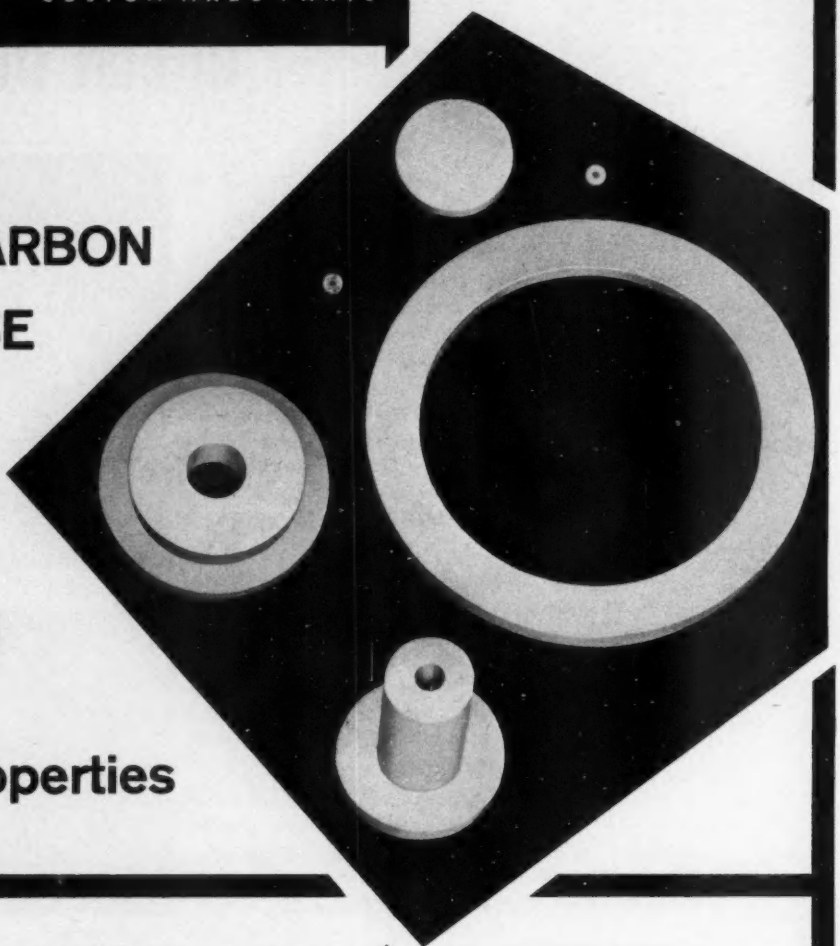

Extensive research has produced a new TFE base material with the following outstanding characteristics:

★ low thermal expansion only one sixth that of PTFE

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★ excellent friction and wear characteristics

★ greater stability against thermal shock

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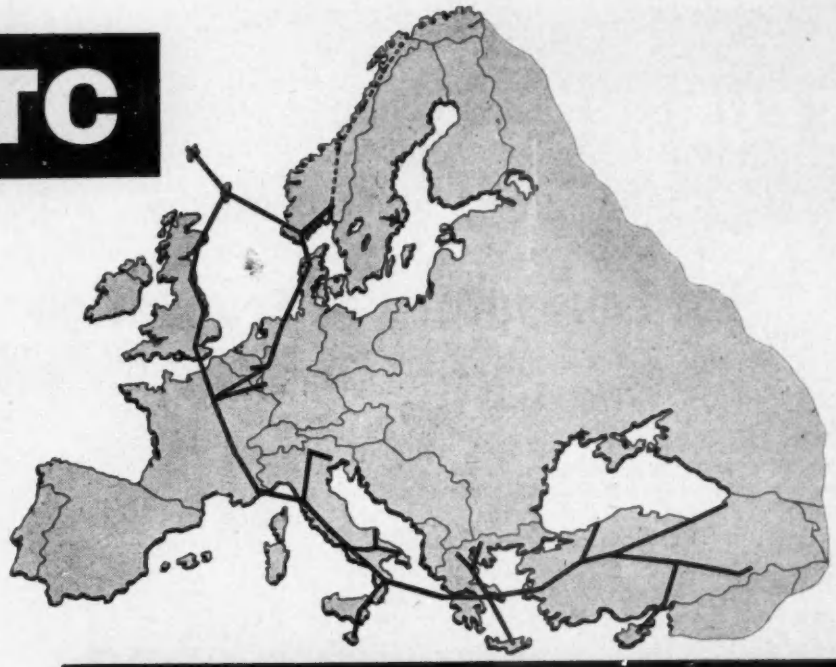
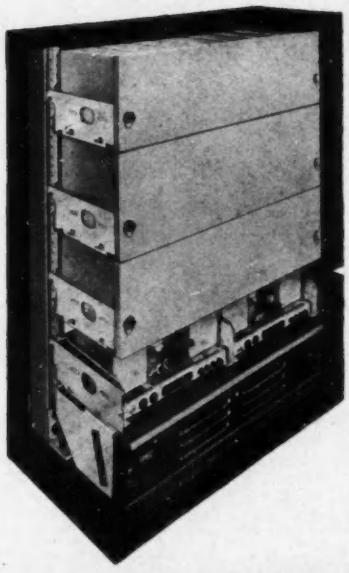


contribution to NATO communications



STC are supplying *Carrier Telephone Multiplex Equipment* for the large NATO radio communications network (ACE-HIGH Project) which will cover Scandinavia, Europe and the Mediterranean. The STC channel, group and supergroup frequency translating equipment will provide over 2 000 channel ends.

STC are also supplying Transmission Testing Equipment, and equipment and visual aids for training courses.

The channel frequency translation equipment is entirely transistor operated and employs the new STC mechanical construction, Type STEP-5. The illustration shows part of a station-rack with a typical 12-circuit group subrack and multigroup power supply equipment below. Plug-in type apparatus units are used.

STC world-wide experience

STC COMMUNICATIONS GROUP

61/16C

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The READ OUT SWITCH FEATURE and the unique "TWO DOT" dialled method of wave-form measurement make this the most accurate oscilloscope available today.

Because of the innumerable types of accurately repeatable measurements that can be made with the Du Mont 425 Oscilloscope, the applications of this instrument are limitless.

FOR PRODUCTION Its "human-engineered" controls and layout eliminates:
Parallax
Scale interpolation
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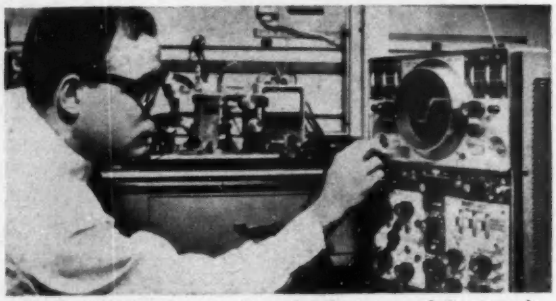
10% or 90% point guesswork in rise or fall time measurements.

Simply assessed wave-form information permits unskilled operators to perform accurate repetitive measurements on complex waveforms.

With the use of the "425" precise complex measurements are reduced to unskilled operations. The DUMONT 404 Pulse Generator can be seen on the left.



The DUMONT 425 being used to analyse the structure of silicon crystals

VERTICAL-DEFLECTION SYSTEM

MAIN FRAME AMPLIFIER

Input	... ...	DC coupled to 36 Mc/s
Rise time	... ...	0.009 microsecond (9nsec)

HORIZONTAL-DEFLECTION SYSTEM

CALIBRATED MAIN SWEEP

Calibrated Sweep Rates	...	From 0.05 microsecond/cm to 2 seconds/cm in 24 steps.
Accuracy	... ...	Adjustable to better than ½% on the 0.05 microsecond/cm range and on one other selected range; all other ranges within 3%.

READ-OUT SYSTEM

Internal Read Out Accuracy

The Read Out system has a normalised accuracy of ½%. The absolute accuracy is within 3%. The calibration may be monitored and adjusted to within ½% of full scale at the 110-volt supply test jack.

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The additional features to those already stated are its wide frequency range, Y Axis 36 Mc/s, X Axis 4 Mc/s, Delay sweep 0.5 μ sec.—10 sec. Each range is divisable by 1000 parts with 3 digit thumb switch controls. The 425 is particularly useful in the general field of medicine, electronics, nuclear energy, radar and solid state physics.

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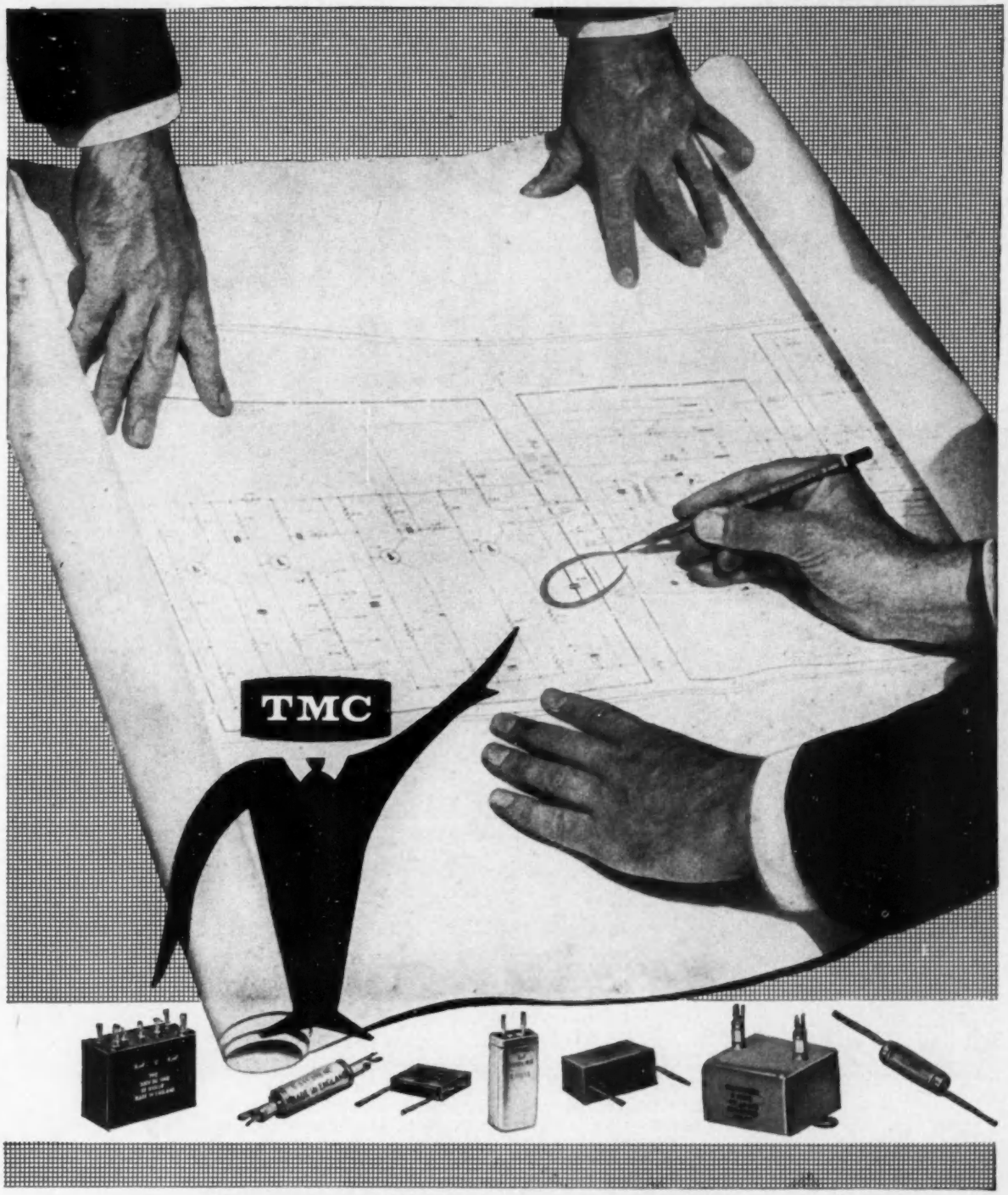

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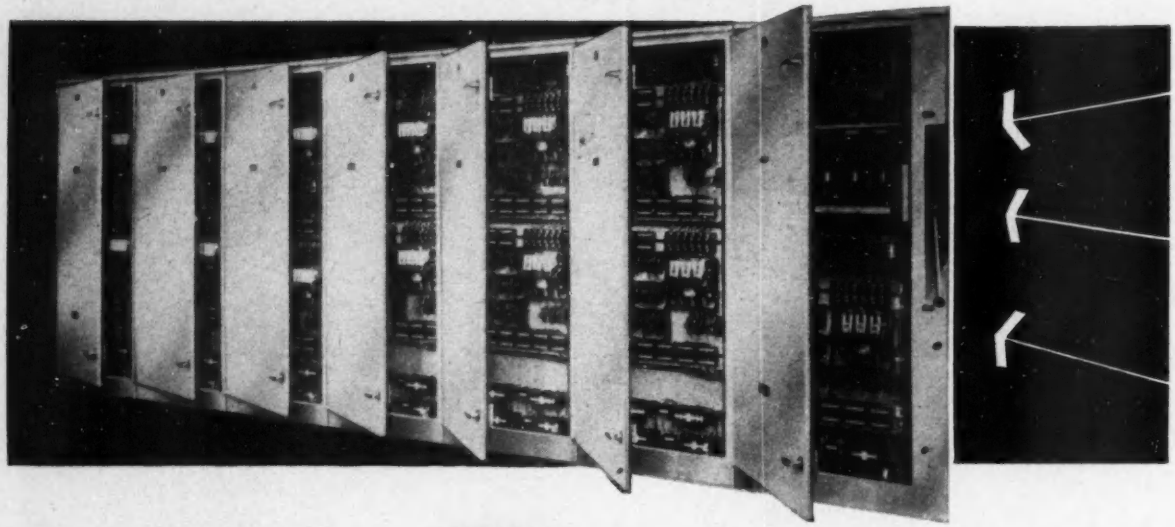
SPECIAL PURPOSE CONTROL PANELS



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This SPECIAL 7-door section of a 13-door Transfer Machine control panel may look like any other switchboard BUT—STANDARD-PROVEN Donovan Contactors, Relays, Overloads, Isolators, and accessories, are used throughout and in addition the panels are plug-in for quick replacement and maintenance—a valuable feature only offered by Donovan.

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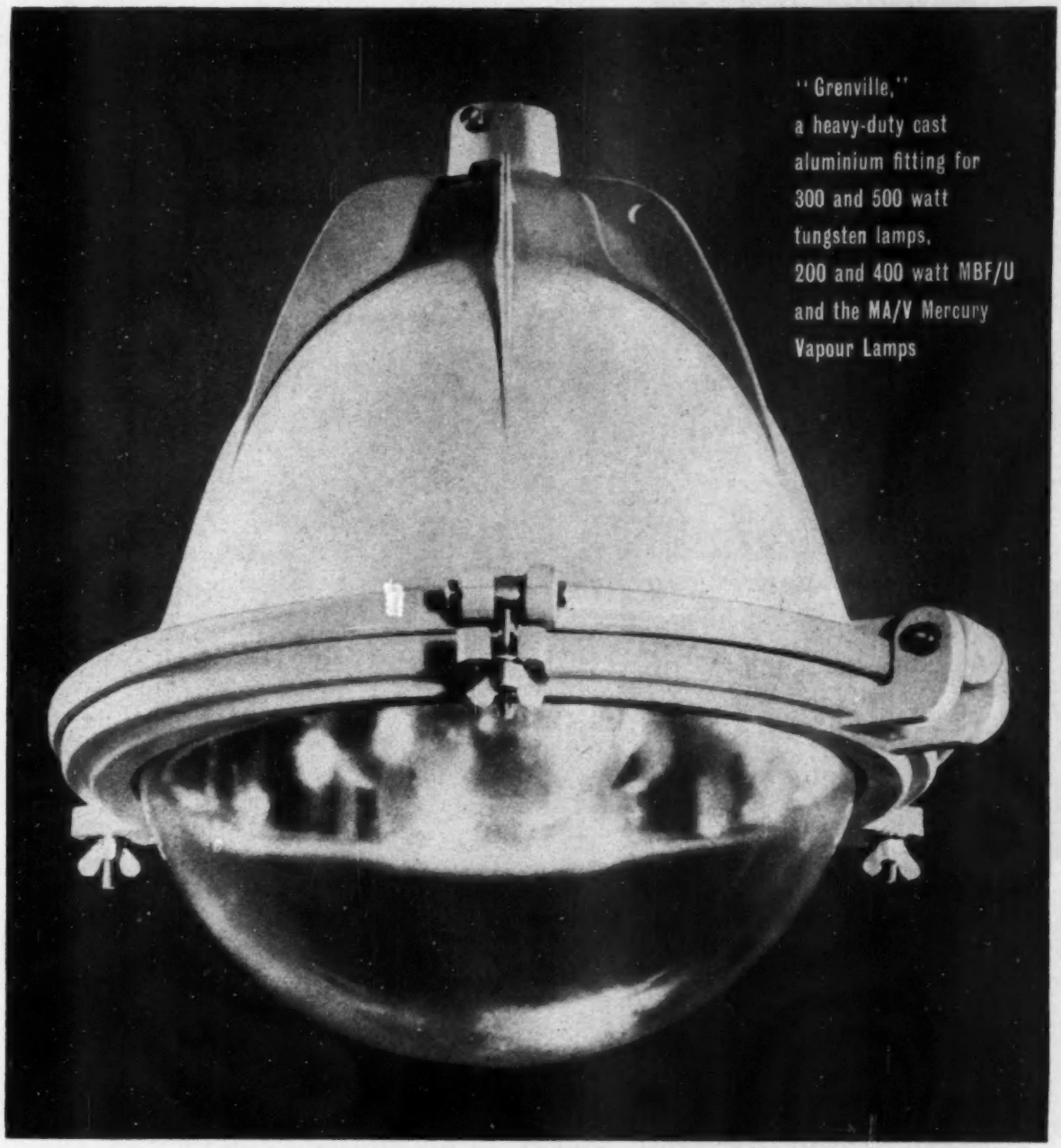

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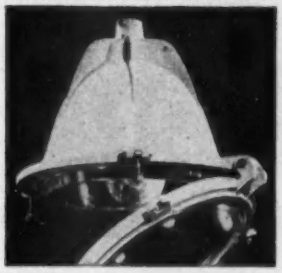

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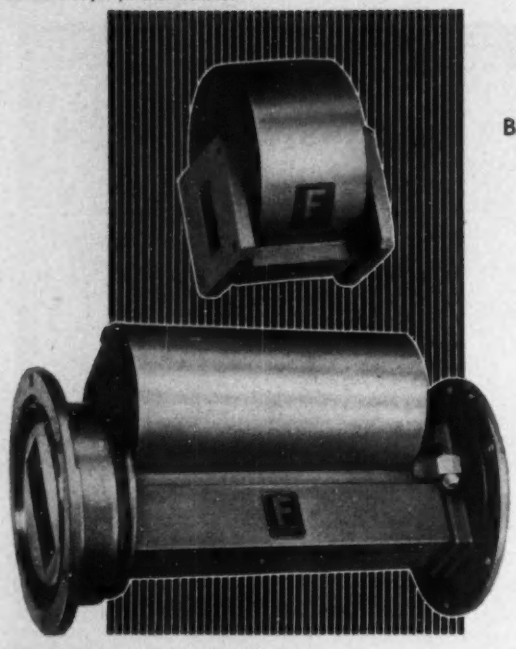

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Range of centre frequencies	8500-10,500 Mc/s
Bandwidth about the centre frequency	±5%
Peak Power	50 KW
Isolation at centre frequency	35db
Isolation over the band	>15db
Weight	2½lb approx

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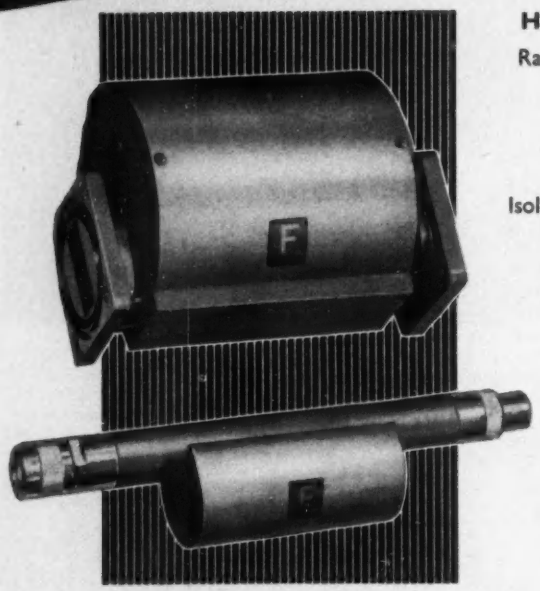

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Range of centre frequencies	8500-10,500 Mc/s
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Isolation at centre frequency	>40db
Isolation over the band	>20db
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Range of centre frequencies	2500-4500 Mc/s
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Isolation over the band	>15db
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Brief Specification:

Range of Collector Voltage:	1·5V to 10·5V (up to 150V using external supplies)
I'co:	First indication 2μA
Base Current:	0-1 mA, 0-40 mA
Collector Current:	0-1A
Beta:	0-25, 0-250 measured at 1 Kc/s
Noise Measurement:	1-20, 21-40 dB

Construction in general conforms with U.K. Inter-Service Spec. K114.

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Range of Heater Voltage:	0·625 – 117·5
Heater Current:	3A max.
Anode Current:	100 mA max.
Mutual Conductance:	0·1 – 60 mA/V max.
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'Gas' Current:	2μA first indication

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Input impedances: On 0·5V range – nominally greater than 5MΩ. On other ranges – 20,000Ω per volt or higher with external attenuator.

Output:
Frequency: 0 – 5 kc/s (full scale).
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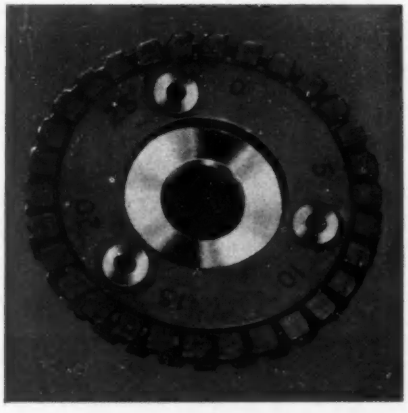
Break-off lobes allow any required periphery— cut time and expense of new cams for experimental applications

The Universal Cam



The Universal Cam, for use with the GEC Ratchet Relay, has been designed to obviate the time and expense of making fresh moulds where only small quantities of non-standard cam are required. Simply by breaking off the unwanted lobes with the tool provided (see illustration), the periphery of the cam may be made to any required shape.

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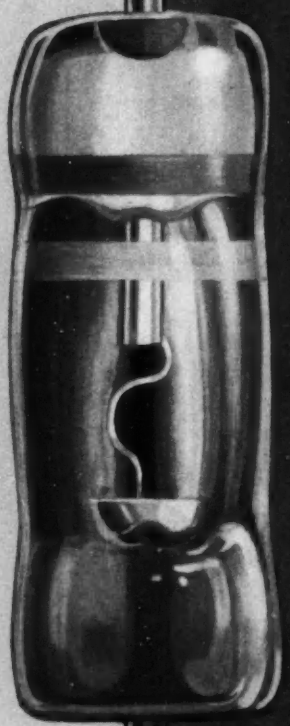

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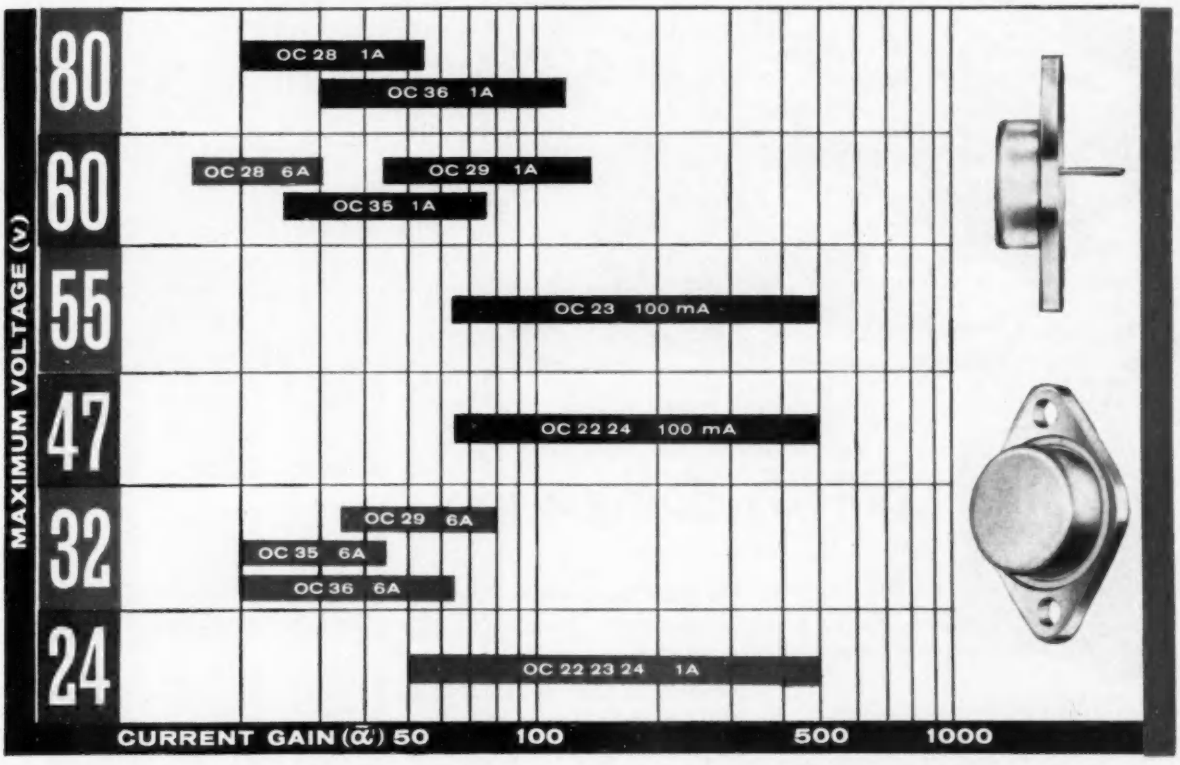
are best selected from this chart

— then you should contact the MULLARD technical information service, who will give you all the data you need to confirm your choice.



RED is maximum allowable collector-emitter voltage at maximum continuous current.

BLACK is maximum allowable collector-base voltage Vcb max. (Ie=0).

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The photograph above shows a gramophone turntable bank in the Sound Control Room at the B.B.C. Television Studios, Lime Grove.

The arm and pick-up of the GLU9 groove locating units are mounted on pairs of SILENTBLOC Square Flange Instrument Type Anti-vibration Mountings, whose purpose is to make quite sure that no ground vibration interferes with the sensitive instruments and spoils absolute perfection of reproduction.

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ELECTROLUMINESCENCE

moves out of the laboratory

As far as we are concerned electroluminescence has ceased to be just an interesting phenomenon—its use is now a practical reality, which lends itself particularly well to data readout applications. For example, all of the characters on the left can be selected at will from one P40 PHOSPHOTRON*.

There are no lenses, no lamps, no moving parts—this is a solid state device with practically no running costs, plus of course extreme reliability. Further, cost per character related to height and variety is considerably cheaper than any other available readout device.

The elements constituting the characters are deposited within ¼" of the front surface, each occupying the same area, which results in an extremely wide-angle viewing, in-line, co-planar display. In the P40 the characters are approximately 4" high giving a readout at distances of up to 200'.

The thickness of the device is less than ½" which means a vital saving of valuable installation space.

For more personalized digital displays Type P21 (1" characters) is also in production.

P40 BRIEF ELECTRICAL AND MECHANICAL DATA

Maximum operating voltage	**250V**
Normal operating voltage	**240V**
Operating frequency range	**50 to 1000 c.p.s.**
Current consumption per element—	
(Nominal at 240V/50 c.p.s.)	**60μAs**
(Nominal at 240V/400 c.p.s.)	**500μAs**
Surface brightness—	
(Nominal at 240V/50 c.p.s.)	**1ft.L**
(Nominal at 240V/400 c.p.s.)	**8 ft.L**

Maximum length	**5.50 in.**	**13.97 cms.**
Maximum breadth	**4.00 in.**	**10.16 cms.**
Maximum thickness	**0.375 in.**	**0.953 cms.**

***Phosphotrons (Ericsson Trade Mark) are standardised components available with green, blue or yellow luminescence.**

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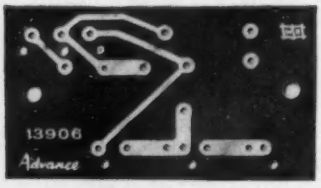
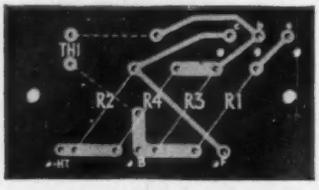
FOR PRINTED CIRCUITS AND COMPONENTS

TWO-FACED CIRCUITS



Printed circuit panel—copper side.



Reverse side with component detail and circuit replica colour printed.

Makes fault location easy. Developed and patented by Mills & Rockleys, the two-faced circuit speeds assembly, and reduces errors in production. One side of the laminate is a normal printed circuit. On the other side, the circuit is colour printed in reverse, together with positions of components to be wired in.

TGA P53

M R

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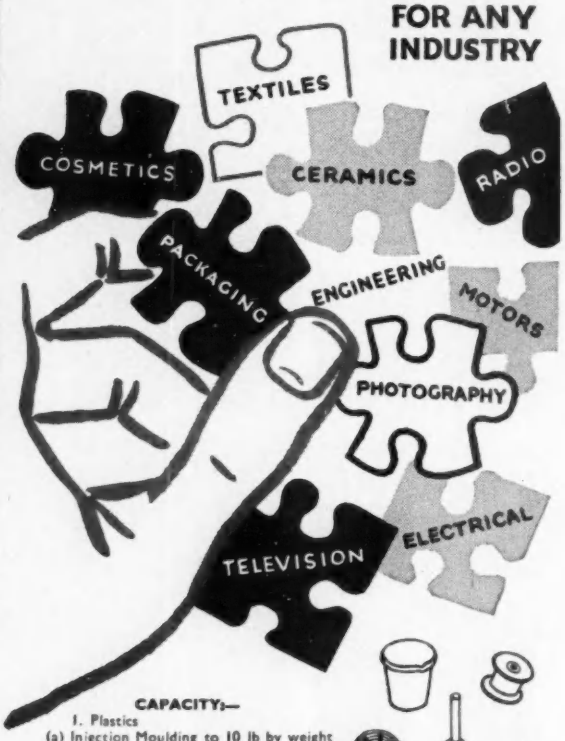

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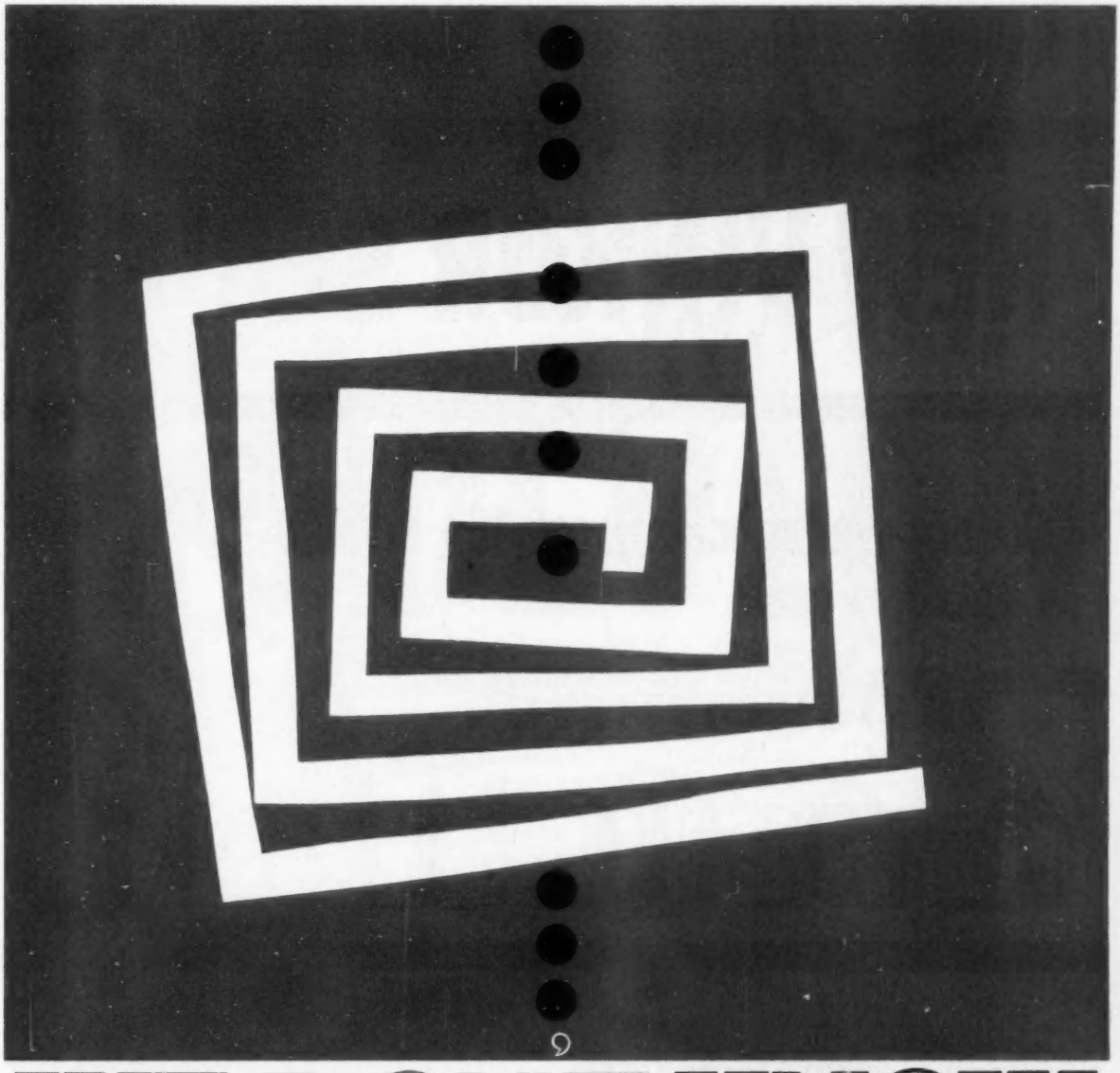

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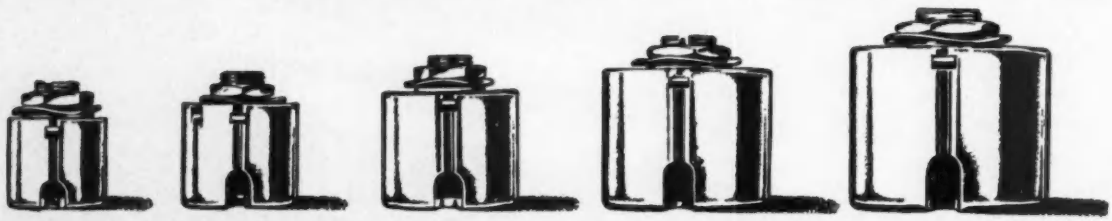

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RESISTANCE TOLERANCE	±5%
LAW ACCURACY	0.05% peak to peak
MAX. WORKING VOLTS. SPINDLE/TRACK	1,000V D.C.
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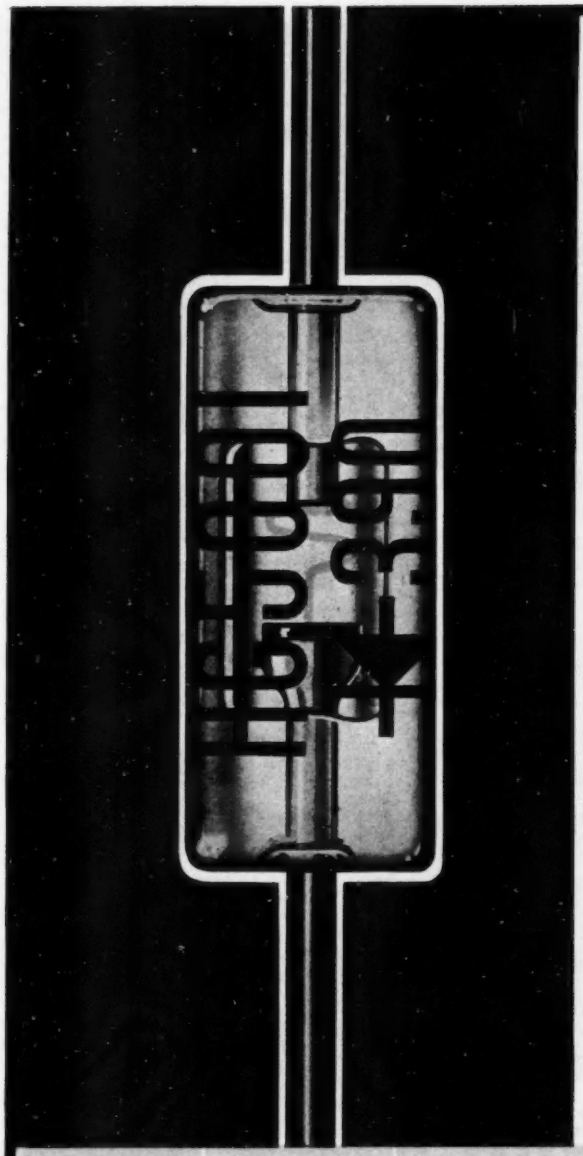

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Type No.	Continuous ratings 25°C		Characteristics 25°C	
	Max. Reverse Volts	Max. Forward Current	Max. Volts Drop	Max. Reverse Current
HG5001	100	80 mA	.8 v @ 100mA	5μA @—50V
HG5002	70	80 mA	.8 v @ 100mA	5μA @—50V
HG5003	100	80 mA	.8 v @ 100mA	25μA @—50V
HG5004	70	80 mA	.8 v @ 100mA	25μA @—50V
HG5005	100	80 mA	.8 v @ 100mA	50μA @—50V
HG5006	70	80 mA	.8 v @ 100mA	50μA @—50V
HG5007	40	80 mA	.8 v @ 100mA	5μA @—30V
HG5008	40	80 mA	.8 v @ 100mA	25μA @—30V
HG5009	40	80 mA	.8 v @ 100mA	50μA @—30V

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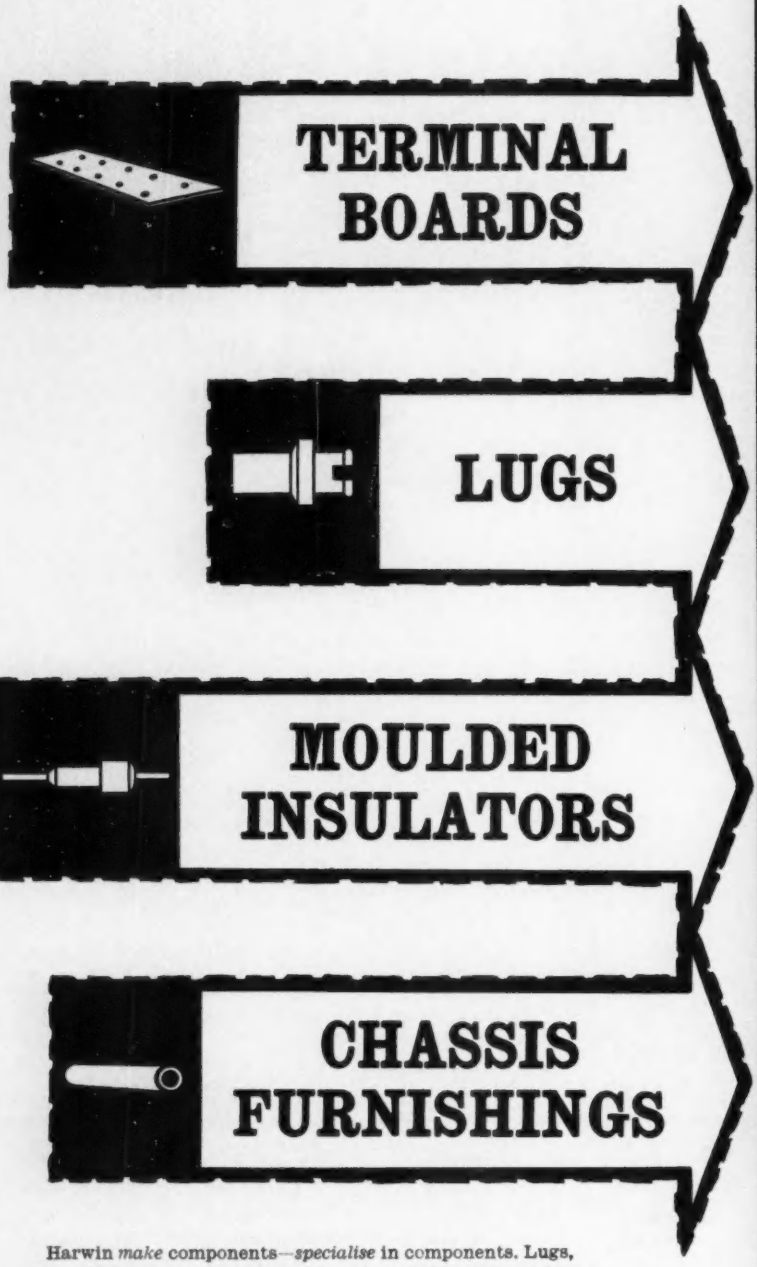

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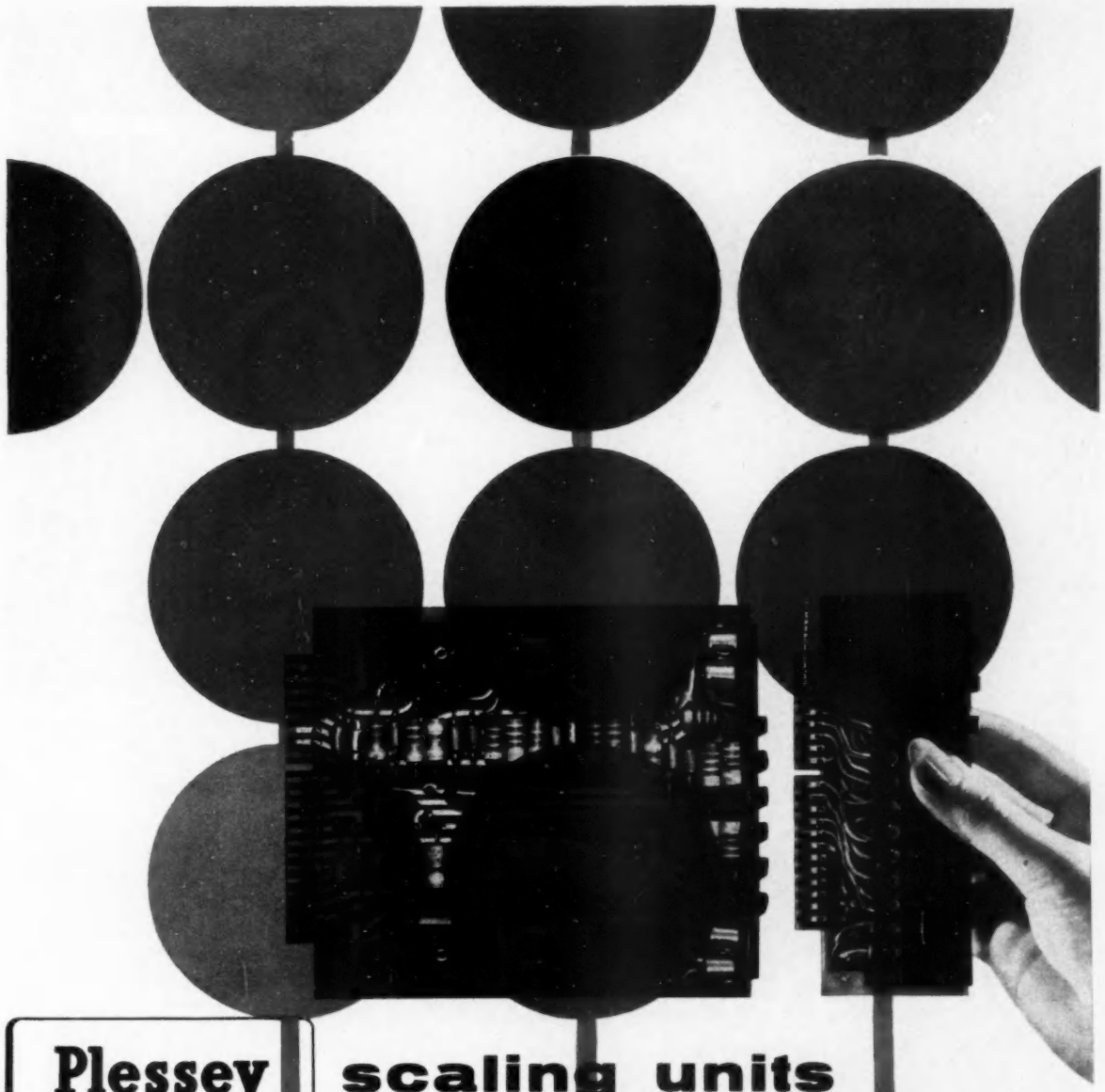

Plessey scaling units

for counting and computing

Plessey Nucleonics are now manufacturing two types of Scaling Unit—a **Decade Scaler** and a **Binary Scaler**. Both are of small overall dimensions and are engineered on plug-in printed circuit boards for general-purpose applications.

The **Decade Scaler** (AERE Type 1694A) has a resolution time of less than 1.5 microseconds and a maximum scaling frequency in excess of 250 kc/s. It provides a 2 microsecond pulse at up to 100 mA and can be stepped by either positive- or negative-going pulses of 0.5 to 1 microsecond width.

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PNL 107

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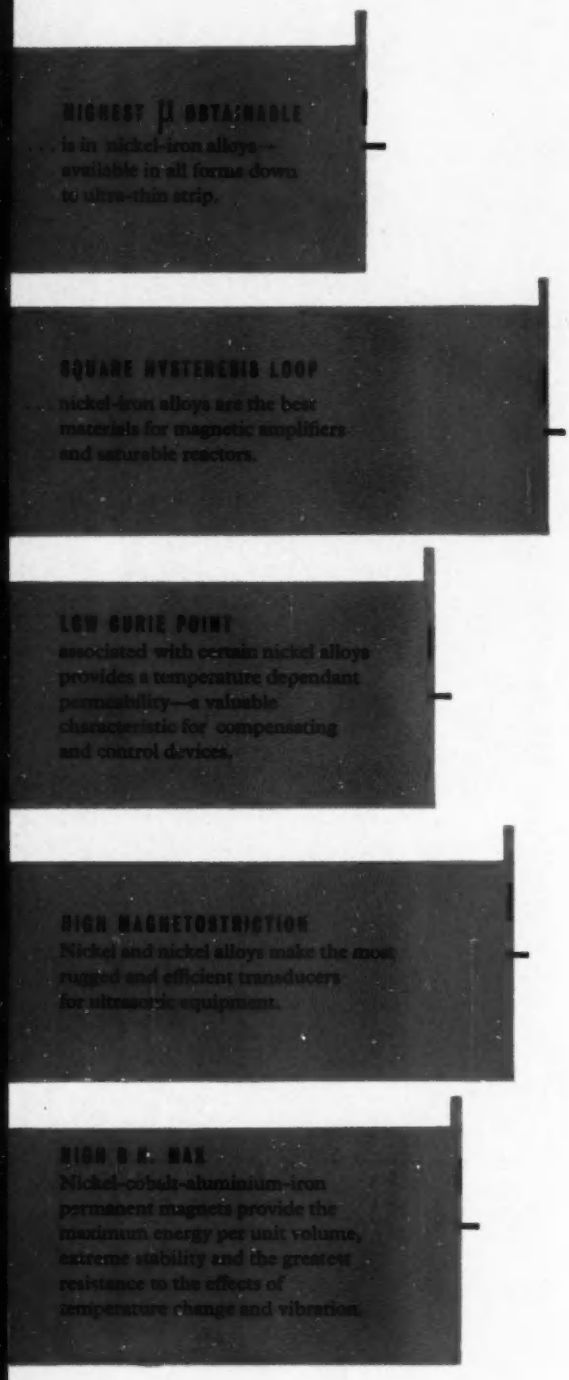
Before specifying magnetic materials consult this record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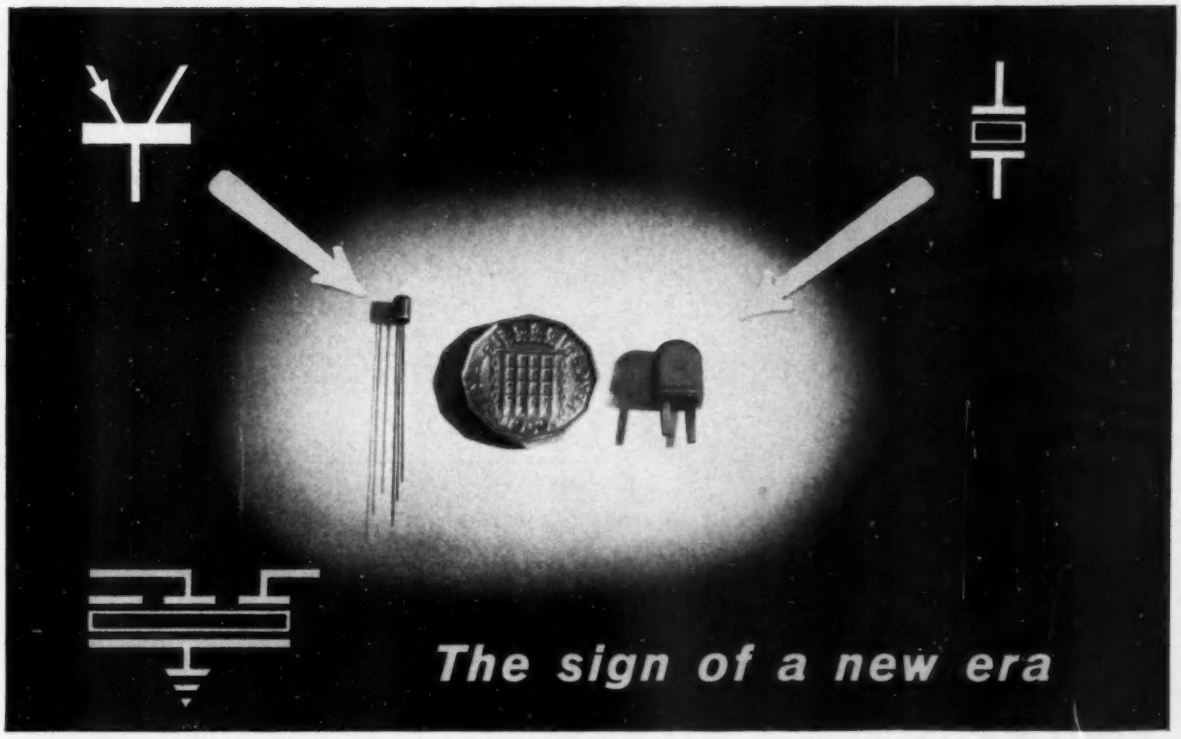

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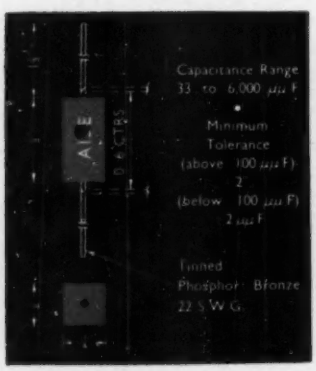

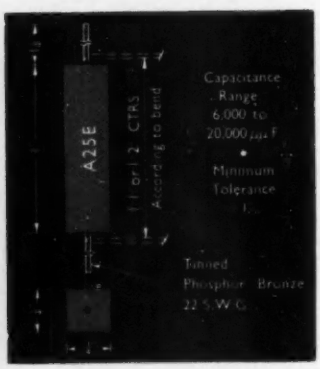

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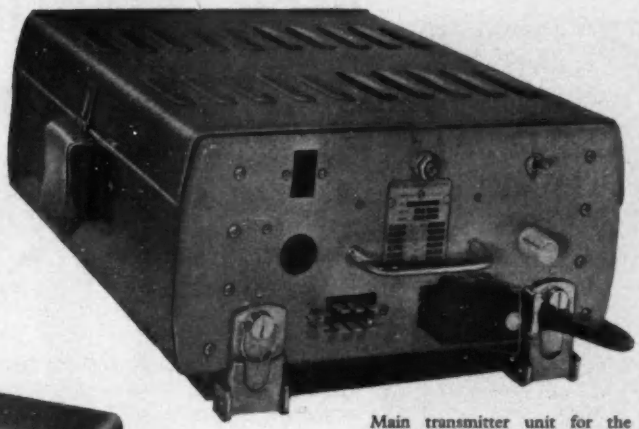

Main transmitter unit for the Pye (PTC 2107) V.H.F., A.M. Mobile Radiotelephone, made by Pye Telecommunications Ltd., Cambridge, in which a number of components made from 'Fluon' p.t.f.e. is used.

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Pye use 'Fluon' components for maximum reliability in 'Ranger' V.H.F. radiotelephones

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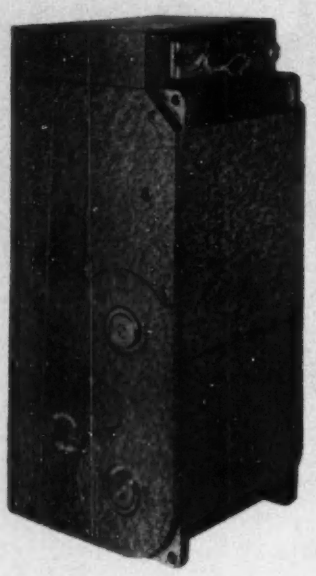

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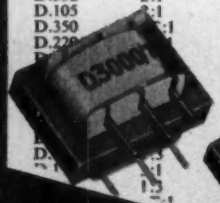

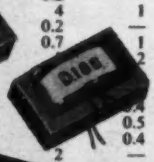

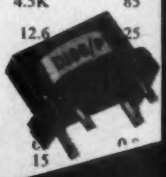

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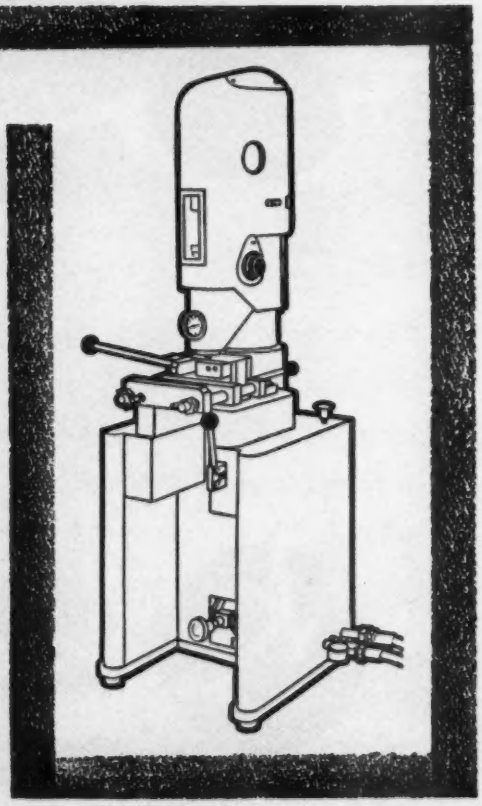

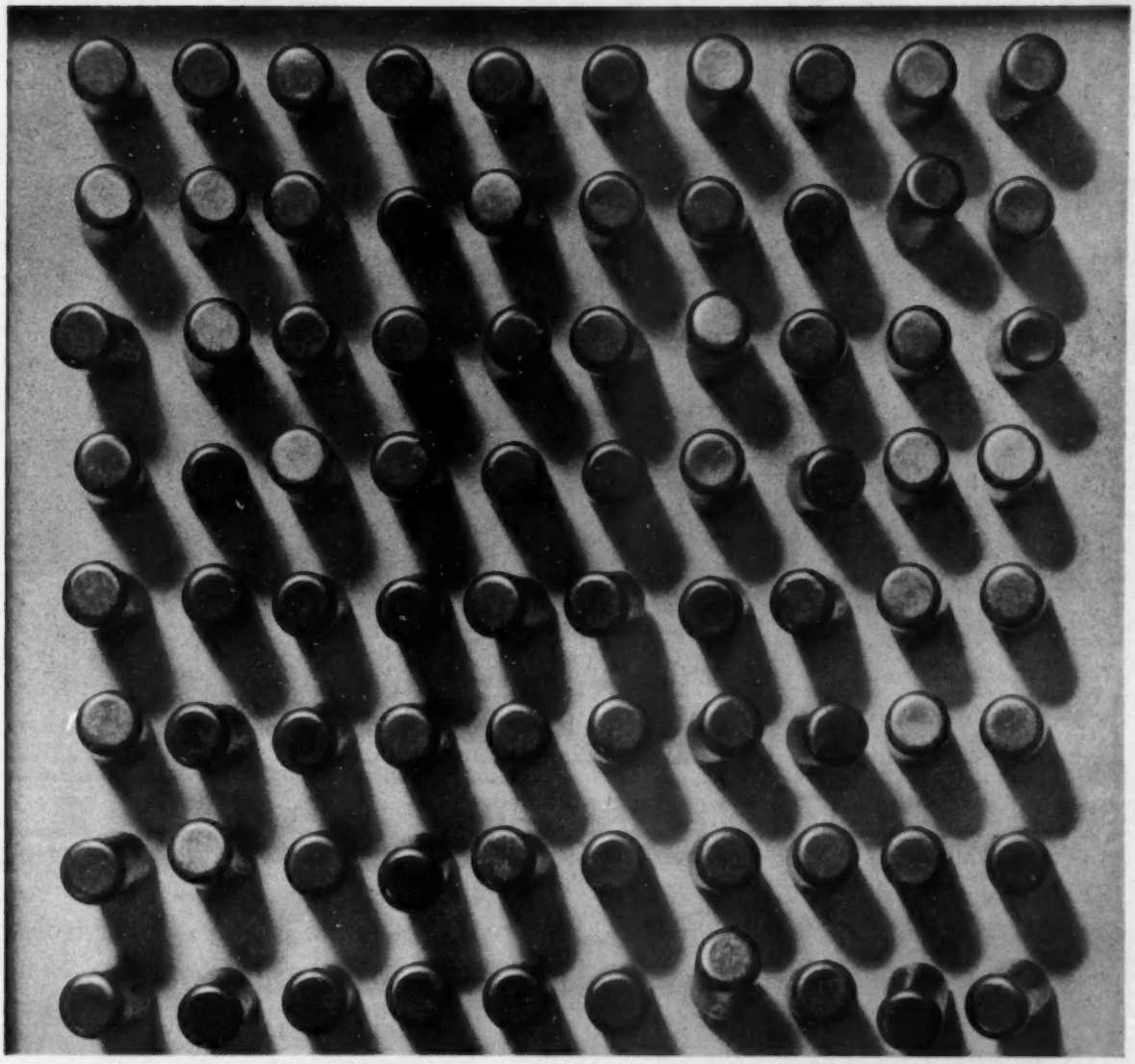

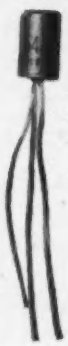

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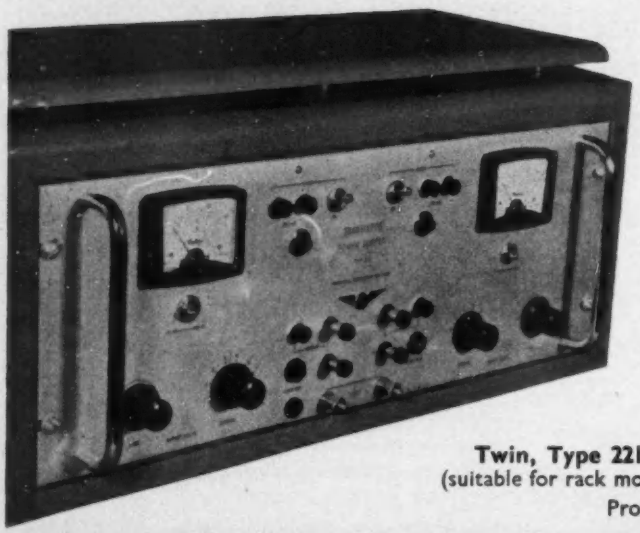

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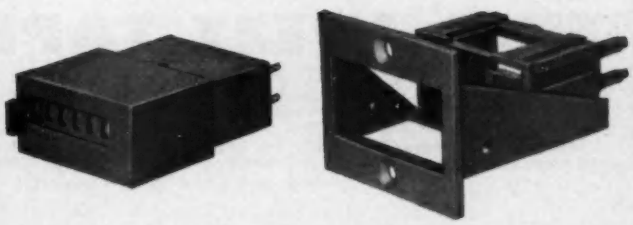

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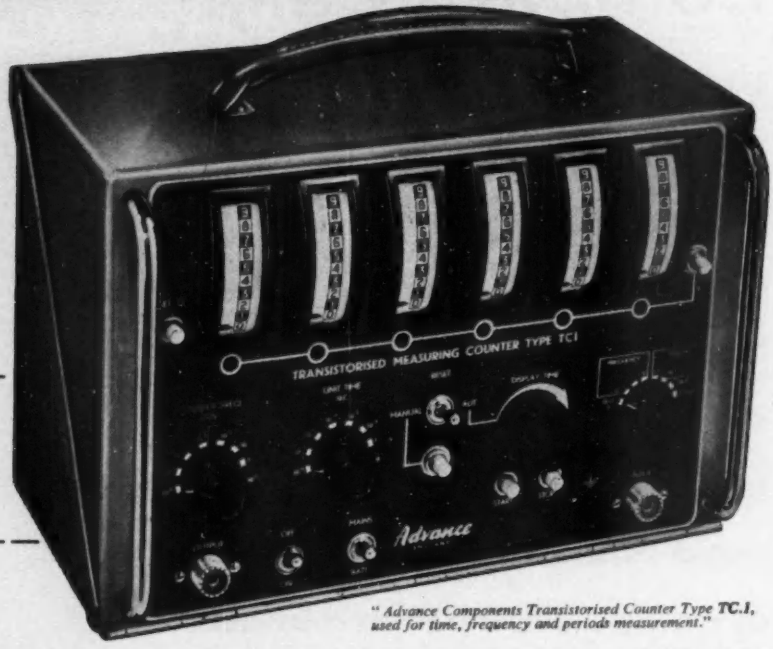

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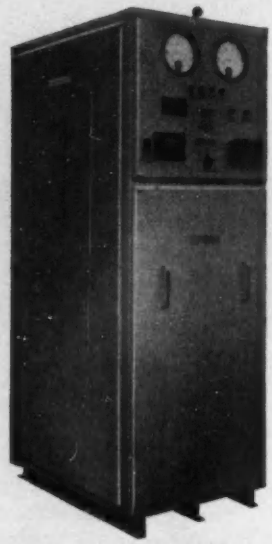

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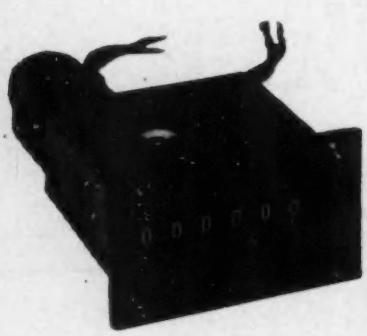

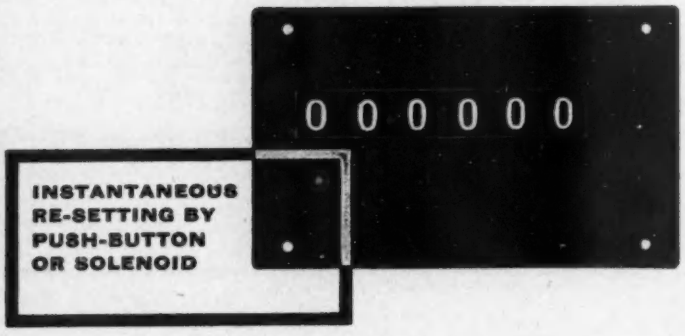

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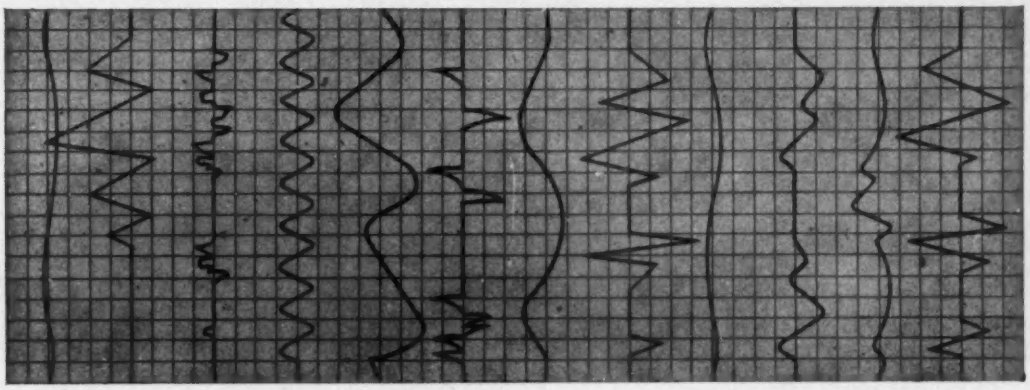

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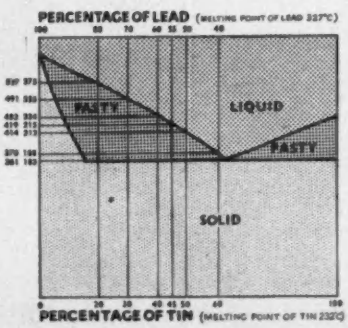
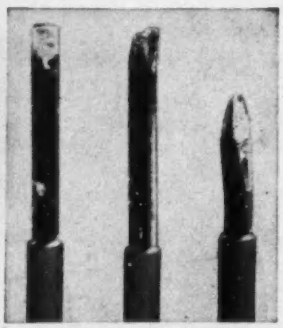
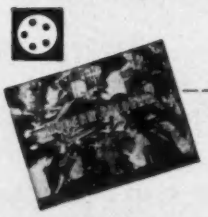

PERCENTAGE OF LEAD (MELTING POINT OF LEAD 327°C)
100 80 70 60 55 50 40
PASTY
LIQUID
PASTY
SOLID
0 20 30 40 45 50 60 100
PERCENTAGE OF TIN (MELTING POINT OF TIN 232°C)



(left) after 10,000 joints with Savbit. (centre & right) after 1,000 and 7,500 joints respectively with standard tin/lead alloy.

PRINTED CIRCUITS

Leaflet P.C.L. 101 gives full details of a complete soldering process developed by Multicore Laboratories for printed circuits.



SAVBIT TYPE 1 ALLOY

Made under sole British Licence of Patent No. 721,881.

Savbit Type 1 alloy was developed after extensive research in the Multicore Laboratories into the main causes of bit wear. It incorporates a small percentage of copper which prevents absorption of copper from the bit into the solder alloy. After prolonged tests, it was found that the life of solder bits was increased by up to 10 times. The speed of soldering is not affected.

SPECIAL ALLOYS

4 special alloys can be supplied for particular purposes:

Comsol with a high melting point of 296°C.

T.L.C. alloy with a melting point of 145°C is made from tin, lead and cadmium.

P.T. (Pure Tin) alloy, with a melting point of 232°C, is lead-free.

L.M.P. alloy, with 2% silver content, which melts at 179°C for silver-coated components.

PUBLICATIONS

Laboratory engineers and technicians are invited to write on their company's letter-heading for the latest edition of Modern Solders. It contains data on melting points, gauges, alloys, etc.

MULTICORE SOLDERS LIMITED, MULTICORE WORKS, HEMEL HEMPSTEAD, HERTFORDSHIRE
TEL: BOXMOOR 3636 (4 LINES) GRAMS AND CABLES: MULTICORE HEMPSTEAD

TA 4902

idm ELECTRONICS LTD

SLIP RINGS

BRUSHES

COMMUTATORS

PRECISION

ROTARY SWITCHES

FROM

30" diameter Slip Ring. Split for ease of assembly. Electrodeposited fine silver rings for lowest noise levels (strain gauge application)

I.D.M. ELECTRONICS offer a complete range of precision sliding contacts.

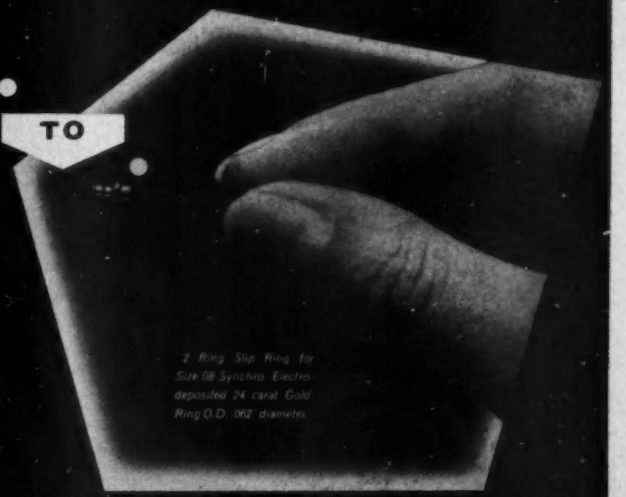
Rings may be of electrodeposited 24 carat Gold or electrodeposited Fine Silver.

This results in

- Unique one piece unitized construction for strength.
- Minimum diameters. Minimum torque.
- No accumulated tolerances.
- 24 carat Gold gives complete freedom from tarnish.
- Lowest electrical noise levels.

* Electro Tec. Corp. Patent No. 748480

TO



2 Ring Slip Ring for Size 08 Synchro. Electrodeposited 24 carat Gold Ring O.D. .062" diameter.

IDM ELECTRONICS LTD.

Whitley Kiln · Basingstoke Road · Reading

Telephone: Reading 82557/8

EE 32 183 *for further details*

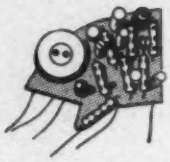
OUTER SPACE ?

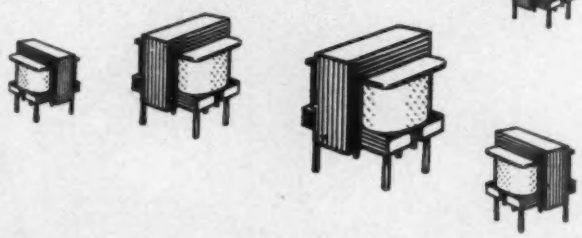
It is an odd thought that as we approach the possibility of travel into space we seem always to be running out of it, yet it is a fact that modern developments are needing such small assemblies that one hardly knows where to turn — except, perhaps, to folk who are quite used to the idea of putting quarts into thimbles.

This, for instance, is a four-stage hearing aid amplifier . . . it really is this size!

And here are some of the miniature transformers which already have a reputation much bigger than themselves, — also in their actual size.

If you happen to suffer from space problems we shall be glad to help in our own small way.



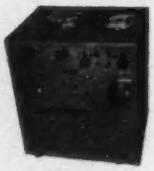


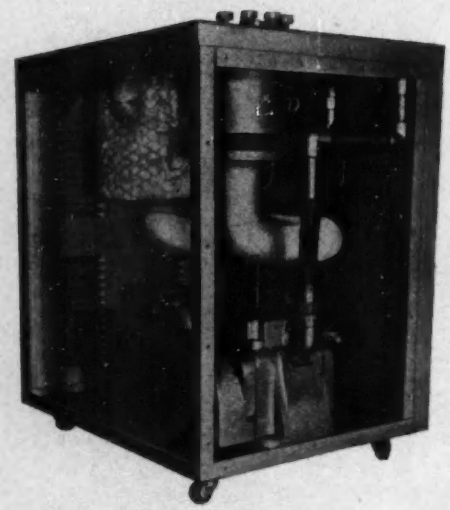
FORTIPHONE
MINIATURE TRANSFORMERS

124-126 DENMARK HILL, LONDON, S.E.5 (Dept. T.2)

RESIN IMPREGNATION

of wire-wound components under vacuum





N.G.N. new 'Resin-impregnating Plant' not only ensures better and far more thorough impregnation of all types of wire coils — its faster cycle of operation, coupled with carefully designed thermostatic control of vessels and pipework, plus full bore resin transfer valve, all combine to speed output while reducing costs.

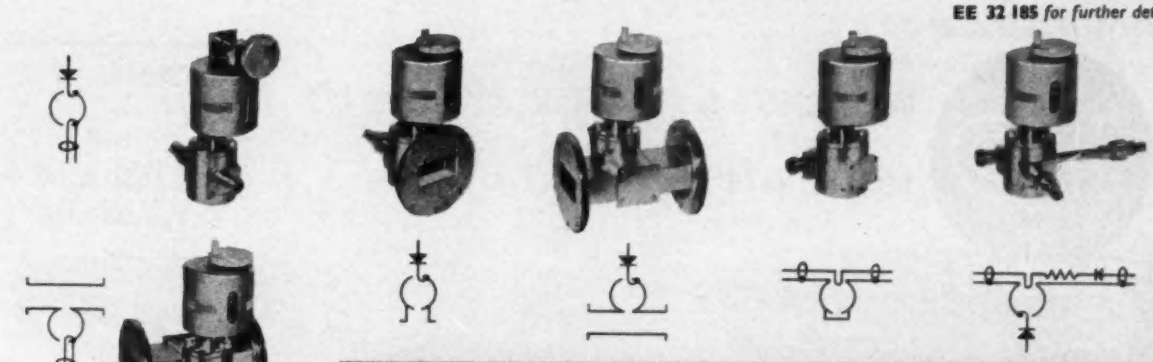
Work chamber is evacuated to 1 micron Hg. to degas and dehydrate components which are then impregnated under a pressure of 80 lbs. p.s.i.

Surplus impregnant is completely recovered. Absolute reliability, both as regards thoroughness of impregnation and regular output is assured.

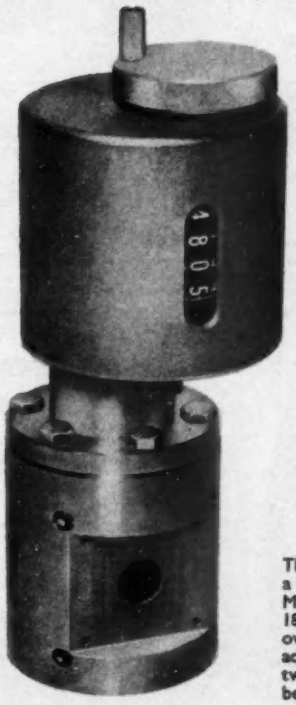
Enquiries for special plant to user requirements are especially welcome.

N.G.N. ELECTRICAL LIMITED
AVENUE PARADE, ACCRINGTON, LANCS. Tel: Accrington 35611-2

EE 32 184 *for further details*



. . . the direct reading frequency meters



Type No.		*Frequency range Mc/s*
SL 7510	-	1100–1700
SL 5815	-	1550–2500
SL 5212	-	2500–4000
SL 5590	-	3300–4900
SL 5174	-	3800–5900
SL 7599	-	4500–7290
SL 5585	-	5400–8600
SL 7100	-	7050–11200
SL 5205	-	8200–12400
SL 7095	-	12400–18000

The photo shows one of the direct reading frequency meters. It may be combined, by means of the different available basic coupling elements, to form various circuit arrangements.

The SIVERS LAB Direct Reading Frequency Meters enable a quick and accurate determination of frequencies in the Microwave region. The frequency range from 1 kMc/s to 18 kMc/s is covered by 10 models. Each model operates over the full waveguide bandwidth, with direct reading accuracy better than $\pm 0.1\%$. The frequency meters have two coupling windows, to which the basic elements can be connected.

Attachments and remote controls are available to enable the Frequency Meter to be included in the interior of a system with the control and frequency indication on the front panel.

For further information about our programme please write for complete catalogue

SIVERS LAB

ELEKTRAVÄGEN 53 P. O. BOX 42018 STOCKHOLM 42, SWEDEN

CABLE: SIVERSLAB

Sales and service: B & K Laboratories Ltd., 4 Tilney Street, Park Lane, London, W.1, Telephone: GROsvenor 4567

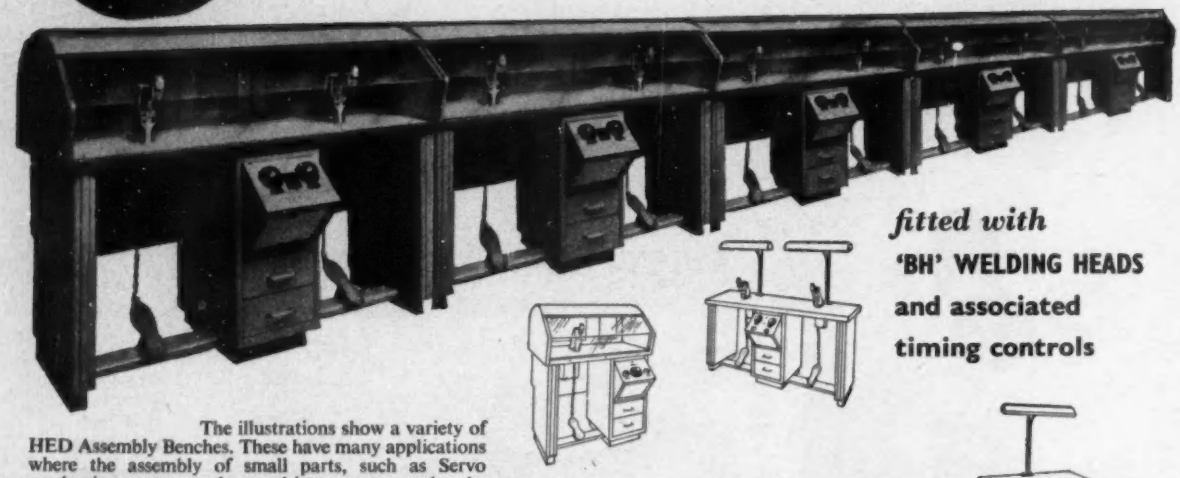
EE 32 186 *for further details*

HED

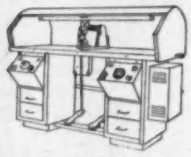
WELDING & ASSEMBLY BENCHES

with air conditioning . . .

STAND 3
ROW X
Empire Hall
ENGINEERING, MARINE & WELDING EXHIBITION

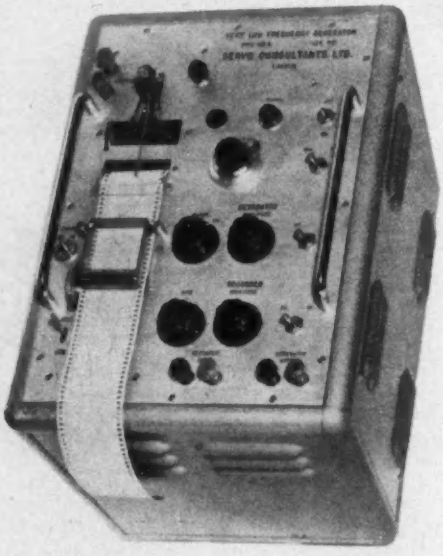


fitted with
'BH' WELDING HEADS
and associated
timing controls



The illustrations show a variety of HED Assembly Benches. These have many applications where the assembly of small parts, such as Servo mechanism, meters, valves and instruments need to be assembled under controlled conditions. Benches can be manufactured to suit particular requirements. Full information available on request.

HIRST ELECTRONIC LTD. GATWICK ROAD,
CRAWLEY, SUSSEX. *Tel: Crawley 25721-2-3*



A sample from our range of servo test gear . . .

SERVO TEST SET TYPE 111R

This versatile instrument can be used as:

VERY LOW FREQUENCY GENERATOR
lowest frequency: 1 cycle/3 hours

AC CARRIER VOLTAGE MODULATOR
carrier frequency: 50 c/s - 5 Kc

SIMPLE HARMONIC RESPONSE TESTER
for either AC or DC systems

HIGH SPEED RECORDER
with response up to 80 c/s

LABORATORY PRECISION VARIABLE SPEED DRIVE:
with speed adjustment accuracy better than 1%

★ *We also manufacture*
Automatic Nyquist Diagram Plotters
Transfer Function Analysers
Very Low Frequency Generators
Stabilised AC Servo Power Supplies
Control Systems Teaching Aids
Instrument Servo Gearboxes
Electronic Limit Switches
Industrial Control Gear

SERVO CONSULTANTS LIMITED
10 BOUVERIE PLACE · LONDON · W.2
Paddington 2811

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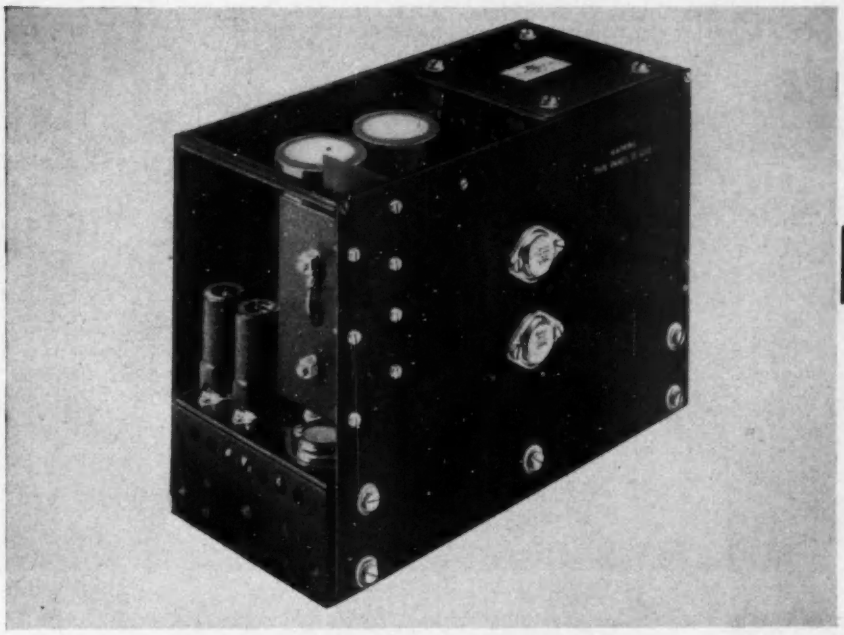


ROBAND

TRANSISTORISED REGULATED POWER SUPPLIES

MODEL	D.C. OUTPUT VOLTS	D.C. OUTPUT AMPS	EFFECTIVE RESISTANCE Ω	% VOLTAGE STABILITY	RIPPLE IN mV	SIZE IN INCHES L	X B	X HT	WEIGHT IN LBS.	EX-WORKS £	S.	D.
T SERIES OPEN CHASSIS PRE-SET VOLTAGE UNITS (Mains 200/250V A.C. 100/125V models available)												
T98	6–18	0·5	0·08	0·1	1·0	5½	2½	4 7/16	3½	32	0	0
T100	30 max.	1·0	0·03	0·1	1·0	7½	4½	5½	5½	45	0	0
T108	50 max.	1·0	0·05	0·1	1·0	8½	5½	6½	8	55	0	0
T109	50 max.	2·0	0·05	0·1	1·0	10½	5½	7½	13	70	0	0
T110	30 max.	5·0	0·01	0·1	1·0	13½	8½	7½	23	98	0	0
T114	30 max.	10·0	0·01	0·1	1·0	17	10	8½	39	135	0	0

Please order as follows: Type No./Voltage required. For example: T109/45 is a 45 volt 2A unit.

T SERIES FRONT PANEL VARIABLE UNITS (Mains 200/250V A.C. 100/125V models available)												
T99	0–±30	0·5	0·1	0·1	1·0	9½	5½	5	8	59	10	0
T101	0–±50	1·0	0·1	0·1	1·0	13½	10½	9½	19½	93	0	0
T102	0–±30	2·0	0·05	0·1	1·0	16½	10½	10½	30	100	0	0
T103	0–±30	1·0	0·05	0·1	1·0	13½	10½	9½	19½	85	0	0
†T104	0–±30 0–±30	1·0 1·0	0·05 0·05	0·1 0·1	1·0 1·0	16½	10½	10½	30	129	0	0
T105	0–±50	2·0	0·05	0·1	1·0	16½	10½	10½	30	118	0	0
T106	0–±100	1·0	0·1	0·1	2·0	*21½	14½	11½	46	149	0	0
T107	0–±100	2·0	0·07	0·1	2·0	*21½	14½	11½	60	183	0	0
T111	0–±50	5·0	0·01	0·1	2·0	*21½	18½	11½	64	155	0	0
T112	0–±50	10·0	0·01	0·1	2·0	*21½	20½	13½	101	245	0	0
T113	0–±30	20·0	0·01	0·1	2·0	*21½	21	16½	139	315	0	0

*Panel and chassis withdrawable to fit 19" rack. †Note that T104 has two independent floating sections.

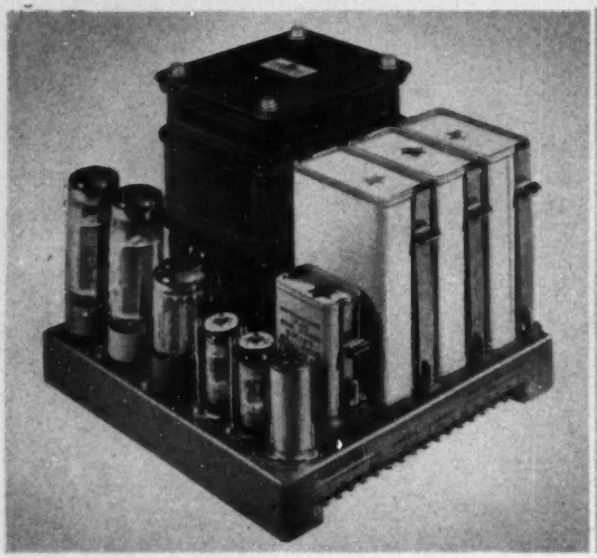
The Roband philosophy of power supplies is to provide *exactly* your *specific* requirements in units of lasting reliability. Roband probably manufacture the widest and most comprehensive range of power supplies available anywhere today. Unrivalled Roband reliability is built into the power supplies by unstinted use of high grade components, interservices approved wherever practical, and by consistently underrunning them – transistors for example at never more than 50% of manufacturers' ratings Painstaking Roband engineering ensures ample ventilation and mechanical strength for the severest conditions.

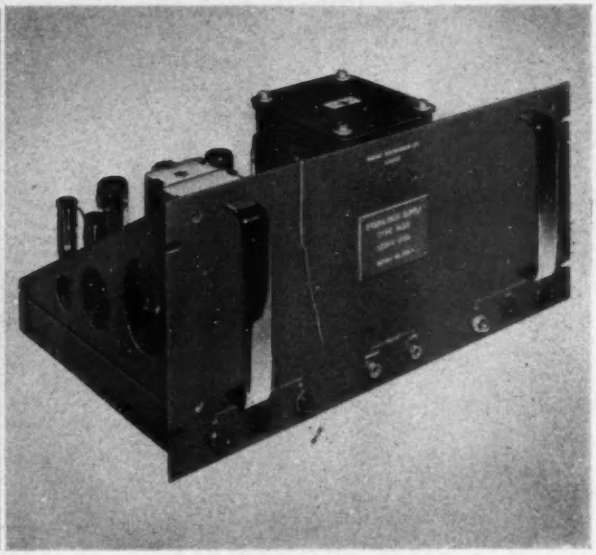
All outputs are isolated to provide highly stabilised positive, negative, or floating supplies with negligible ripple.

Open chassis units are supplied pre-set to any voltage from zero nominal to maximum, a pre-set control allowing a small variation. Any other voltage can be obtained by simple adjustment within the unit.

Made and guaranteed by

ROBAND ELECTRONICS LIMITED
BEULAH WORKS, BEULAH ROAD,
THORNTON HEATH, SURREY
Telephone: LIVingstone 6606





ROBAND

VACUUM TUBE REGULATED

MODEL	D.C. OUTPUT VOLTS	D.C. OUTPUT mA	A.C. OUTPUTS IN AMPS. (ALL 6.3V)	EFFECTIVE RESISTANCE (Ω)	% VOLTAGE STABILITY	RIPPLE IN mV	SIZE IN INCHES L x B x HT.	WEIGHT IN LBS.	EX-WORKS £ S. D.
M SERIES OPEN CHASSIS UNITS (Mains 200/250V A.C. 115V models available)									
M22	±150	0-20	Nil	0·1	0·02	1·0	4½ 3½ 4½	2½	26 0 0
M22A	±200	0-20	Nil	0·1	0·02	1·0	4½ 3½ 4½	2½	26 0 0
M23	±150	0-50	2 & 1	0·1	0·02	1·0	6 5½ 5½	6	27 10 0
M23A	±200	0-50	2 & 1	0·1	0·02	1·0	6 5½ 5½	6	27 10 0
M33	±250	0-50	2 & 1	0·1	0·02	1·0	6 5½ 5½	6	27 10 0
M33A	±300	0-50	2 & 1	0·1	0·02	1·0	6 5½ 5½	6	27 10 0
M14A	±100	0-100	3 & 3	1·0	0·02	1·0	10½ 7 6½	14½	63 0 0
M24	±150	0-100	3 & 3	0·1	0·02	1·0	7½ 6½ 6½	12½	33 10 0
M24A	±200	0-100	3 & 3	0·1	0·02	1·0	7½ 6½ 6½	12½	33 10 0
M34	±250	0-100	3 & 3	0·1	0·02	1·0	7½ 6½ 6½	12½	33 10 0
M34A	±300	0-100	3 & 3	0·1	0·02	1·0	7½ 6½ 6½	12½	33 10 0
M25	±150	0-200	3 & 3	0·1	0·02	1·0	8½ 8½ 7	20	52 10 0
M25A	±200	0-200	3 & 3	0·1	0·02	1·0	8½ 8½ 7	20	52 10 0
M35	±250	0-200	3 & 3	0·1	0·02	1·0	8½ 8½ 7	20	52 10 0
M35A	±300	0-200	3 & 3	0·1	0·02	1·0	8½ 8½ 7	20	52 10 0
M26S	±150	30-500	5 & 5	0·1	0·02	1·0	14 11½ 8	20	88 0 0
M26SA	±200	0-500	5 & 5	0·1	0·02	1·0	14 11½ 8	35½	88 0 0
M36S	±250	0-500	5 & 5	0·1	0·02	1·0	14 11½ 8	35½	88 0 0
M36SA	±300	0-500	5 & 5	0·1	0·02	1·0	14 11½ 8	35½	88 0 0
M28	±150	30-350	5 & 5	0·1	0·02	1·0	13½ 8½ 6½	29	66 0 0
M28A	±200	0-350	5 & 5	0·1	0·02	1·0	13½ 8½ 6½	29	66 0 0
M38	±250	0-350	5 & 5	0·1	0·02	1·0	13½ 8½ 6½	29	66 0 0
M38A	±300	0-350	5 & 5	0·1	0·02	1·0	13½ 8½ 6½	29	66 0 0
M SERIES FRONT PANEL UNITS (Mains 200/250V A.C. 115V models available)									
M26	±150	30-500	5 & 5	0·1	0·02	1·0	19 12 8½	46½	97 10 0
M26A	±200	0-500	5 & 5	0·1	0·02	1·0	19 12 8½	46½	97 10 0
M36	±250	0-500	5 & 5	0·1	0·02	1·0	19 12 8½	46½	97 10 0
M36A	±300	0-500	5 & 5	0·1	0·02	1·0	19 12 8½	46½	97 10 0
M27	±150	50-1·0A	5 & 5	0·1	0·02	1·0	19 15½ 8½	50½	165 0 0
M27A	±200	0-1·0A	5 & 5	0·1	0·02	1·0	19 15½ 8½	50½	165 0 0
M37	±250	0-1·0A	5 & 5	0·1	0·02	1·0	19 15½ 8½	50½	165 0 0
M37A	±300	0-1·0A	5 & 5	0·1	0·02	1·0	19 15½ 8½	50½	165 0 0
M29	±150	100-2·0A	5 & 5	0·1	0·C2	1·0	19 18 10½	82½	255 0 0
M29A	±200	0-2·0A	5 & 5	0·1	0·02	1·0	19 18 10½	82½	255 0 0
M39	±250	0-2·0A	5 & 5	0·1	0·02	1·0	19 18 10½	82½	255 0 0
M39A	±300	0-2·0A	5 & 5	0·1	0·02	1·0	19 18 10½	82½	255 0 0

ALL C.T.

B SERIES

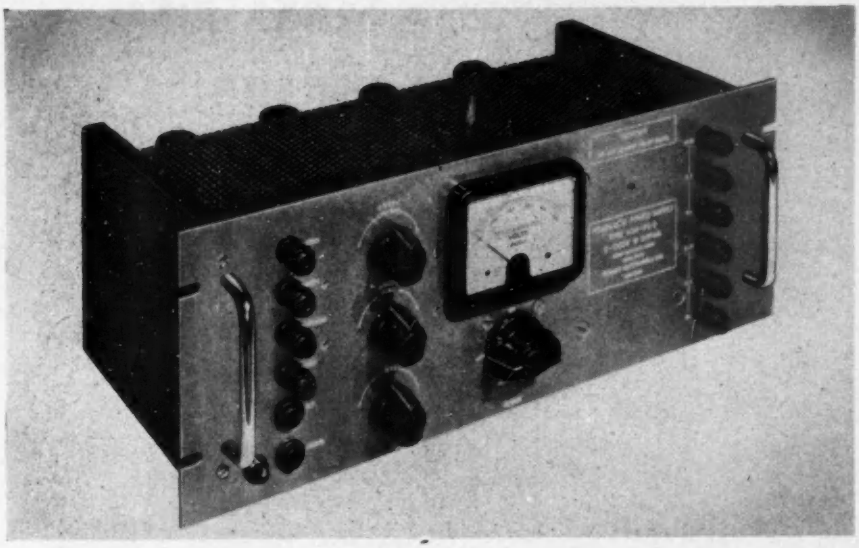
Rugged reliable units

Probably the most advanced series of open chassis units available today and characterised by an extremely rugged construction and a line-up of inter-services approved reliable valves. The input and outputs terminate on Plessey Mark 4 connectors (or any suitable alternative if requested) and a mains selector panel is included.

A compact welded rectangular framework of extruded angle aluminium alloy rigidly secures the 'C' core transformer and the 14 S.W.G. chassis housing the electronic sub-assembly. Because all the vulnerable components are located within the framework the risk of accidental damage is greatly minimised.

The framework contains anchor nuts which facilitate mounting the units in a variety of ways. It is permissible, for instance to secure any two units side by side to a standard 19" x 7" front panel.

High efficiency silicon junction rectifiers, series valves operating as pentodes and a 'C' core transformer to H2 specification ensure a minimum temperature rise within the unit. Insulated carbon and vitreous wire-wound resistors are used throughout and the conservative design permits continuous operation at full load even when the mains are permanently ±10% from nominal.



POWER SUPPLIES

ROBAND

MODEL	D.C. OUTPUT VOLTS	D.C. OUTPUT mA	A.C. OUTPUTS IN AMPS. (ALL 6.3V)	EFFECTIVE RESISTANCE Ω	% VOLTAGE STABILITY	RIPPLE IN mV	SIZE IN INCHES L x B x HT.	WEIGHT IN LBS.	EX-WORKS £ S. D.
B SERIES RUGGED RELIABLE UNITS (Mains 200/250V A.C. & 100/125V A.C.)									
B101/150	-150	30-150	3 & 3	0·1	0·02	1·0	9½ 7½ 6½	16	55 0 0
B101/200	±200	0-150	3 & 3	0·1	0·02	1·0	9½ 7½ 6½	16	55 0 0
B101/250	±250	0-150	3 & 3	0·1	0·02	1·0	9½ 7½ 6½	16	55 0 0
B101/300	±300	0-150	3 & 3	0·1	0·02	1·0	9½ 7½ 6½	16	55 0 0
B101/350	±350	0-100	3 & 3	0·1	0·02	1·0	9½ 7½ 6½	16	55 0 0
B102/150	±150	30-300	5 & 5	0·1	0·02	1·0	14½ 7½ 6½	24	75 0 0
B102/200	±200	0-300	5 & 5	0·1	0·02	1·0	14½ 7½ 6½	24	75 0 0
B102/250	±250	0-250	5 & 5	0·1	0·02	1·0	14½ 7½ 6½	24	75 0 0
B102/300	±300	0-250	5 & 5	0·1	0·02	1·0	14½ 7½ 6½	24	75 0 0
B102/350	±350	0-200	5 & 5	0·1	0·02	1·0	14½ 7½ 6½	24	75 0 0
B103/150	±150	30-500	5 & 5	0·1	0·02	1·0	16½ 8 6½	32	95 0 0
B103/200	±200	0-500	5 & 5	0·1	0·02	1·0	16½ 8 6½	32	95 0 0
B103/250	±250	0-500	5 & 5	0·1	0·02	1·0	16½ 8 6½	32	95 0 0
B103/300	±300	0-500	5 & 5	0·1	0·02	1·0	16½ 8 6½	32	95 0 0
B103/350	±350	0-400	5 & 5	0·1	0·02	1·0	16½ 8 6½	32	95 0 0

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V50-20D A 0 to 500V 200mA (restricted to 150mA below 200V) unit of moderate performance. A regulated variable negative rail from 0 to 85V via a 100K potentiometer and two 6.3V5A centre tapped windings are included. A coarse control varies the output from 0 to 500V in one continuous sweep and a fine control is included.

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2V35-25. A very compact unit containing several regulated output voltages. There are two 0 to 350V 250mA sections which may be operated separately, in parallel or in series. Each section has a coarse control to vary the output from 0 to 350V in one sweep and a fine control is included. A fixed 250V 50mA rail and two 6.3V5A centre tapped windings are provided.

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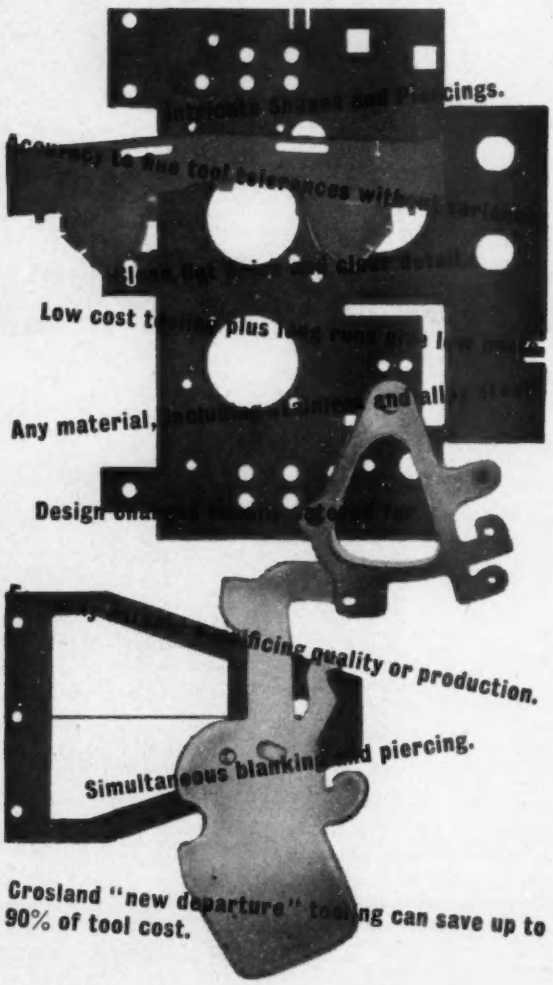

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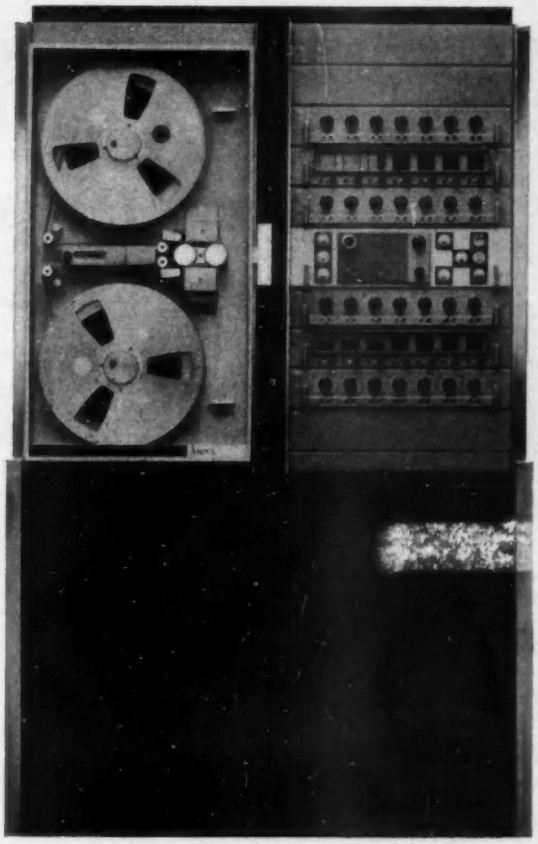

The AMPEX FR-600 is an advanced-design data recorder with twice the capacity of conventional recorders. Most analogue recorders can only record 24 minutes of 100 Kc data on a 14-inch reel of 1 mil tape. The FR-600 will record 48 minutes of the same data on the same reel of tape. The reason – greater bandwidth at a given speed . . . 125 Kc at 30 ips, for example. Many data-runs are 30 minutes or longer, requiring a stand-by recorder to pick up where the first leaves off . . . an expensive price for a few extra minutes of recording time. The FR-600 literally does the work of two conventional machines by enabling double record time for any given bandwidth, or double bandwidth for any given record time . . . 250 Kc at 60 ips, for example. Another cost-saving feature is the tape shuttle which automatically scans any portion of the tape, eliminating the need for a separate loop recorder. Modular plug-in, solid-state electronics warm up in less than 10 minutes, and FM amplifier drift is less than one percent in 24 hours. Other advanced features of the FR-600 include pneumatic tape guiding, tension sensing and control, adjustable search speed and fourteen miniature monitor oscilloscopes. For complete information write Ampex Great Britain Limited, Arkwright Road, Reading, Berkshire, England. AMPEX

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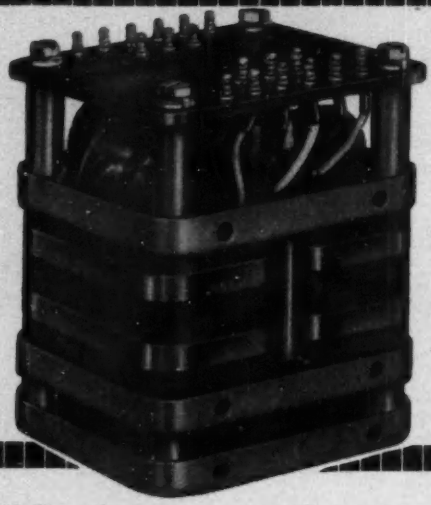

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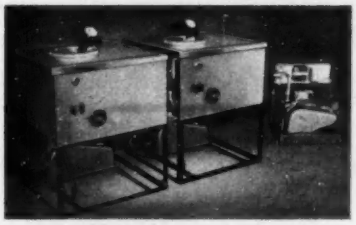

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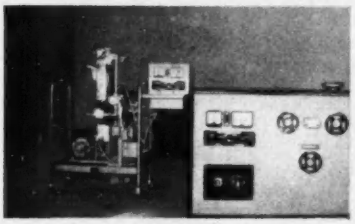

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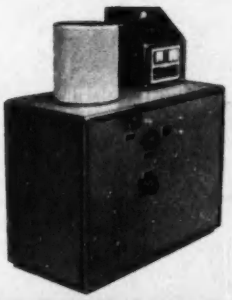

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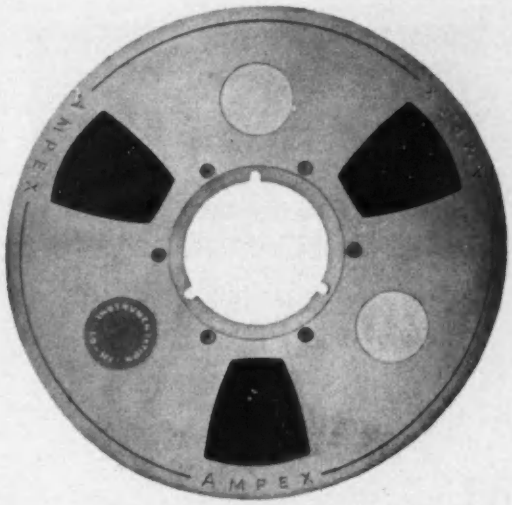

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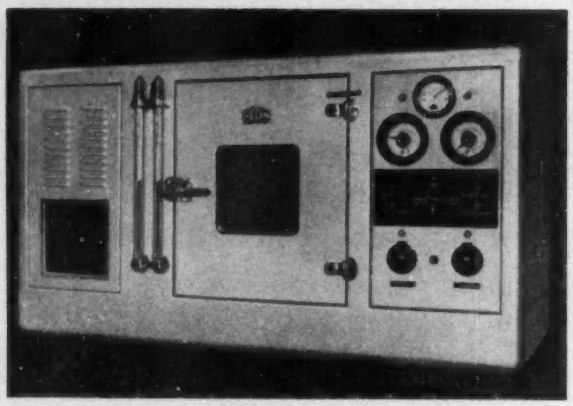

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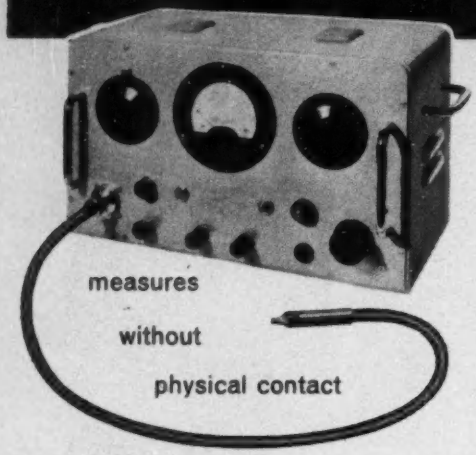

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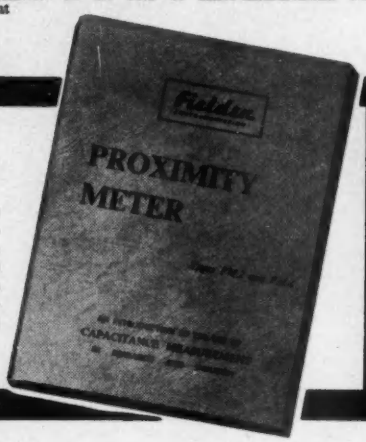

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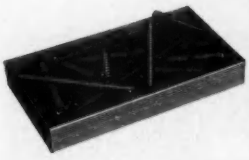

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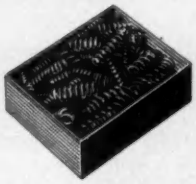

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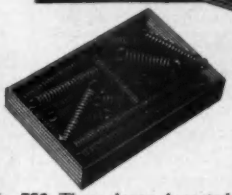

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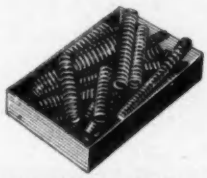

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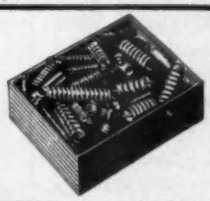

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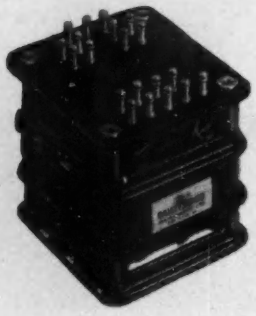

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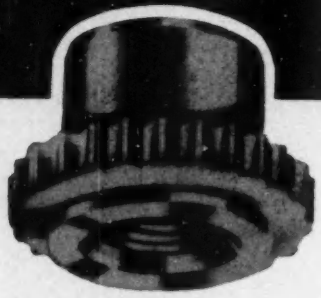

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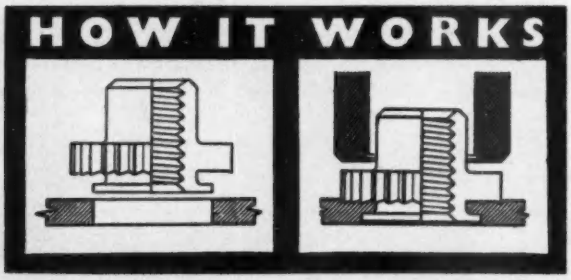

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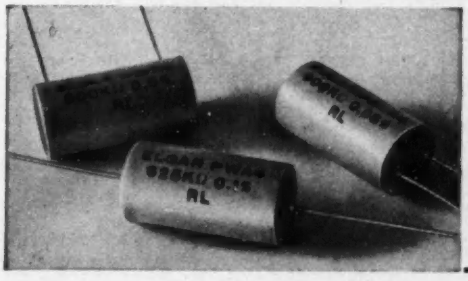

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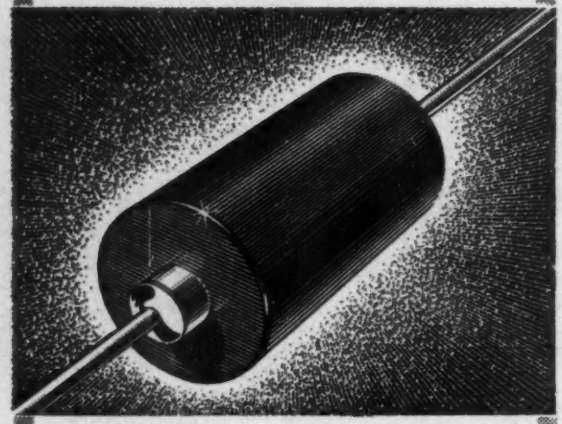

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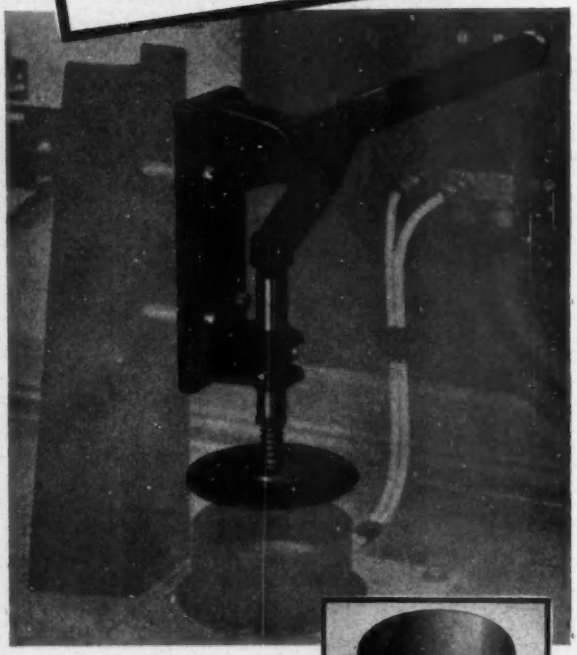

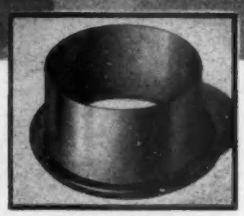

BRAZING

The illustration shows a BRAUER 'Quick-Action' TOGGLE CLAMP Type TC.62 being used to meet the requirements of efficient induction brazing—quick positive clamping and instant releasing—at Radio Heaters Ltd., Wokingham.

This brazing fixture incorporating a BRAUER Clamp has achieved considerable saving of time and money in the production of meter cases (see inset photograph).

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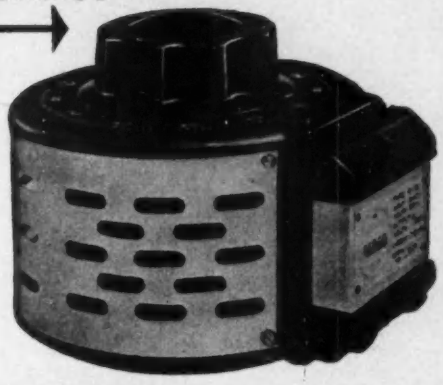

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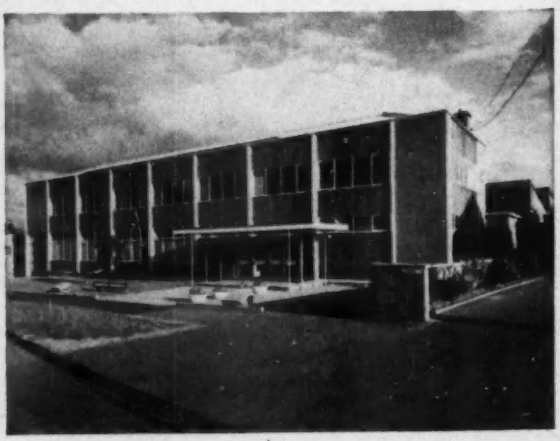

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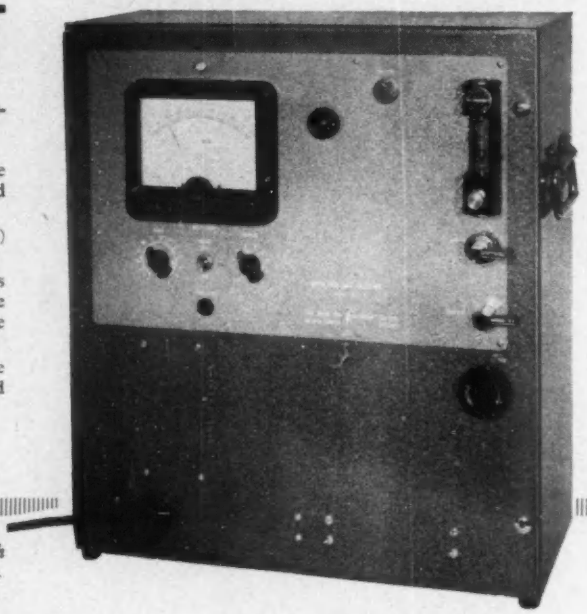

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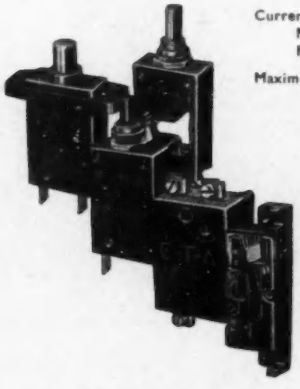

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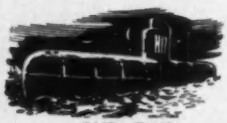

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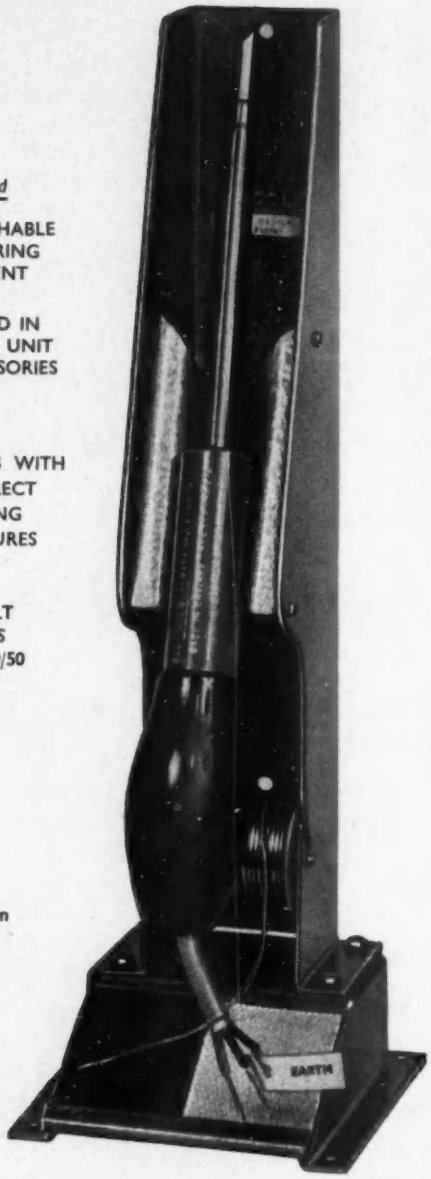

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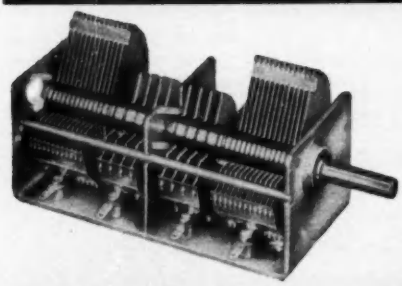

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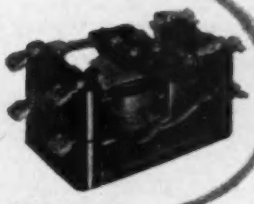

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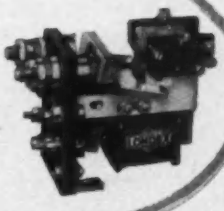

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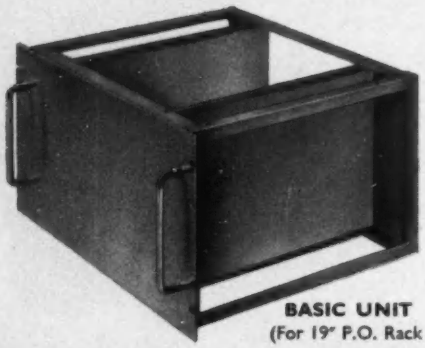

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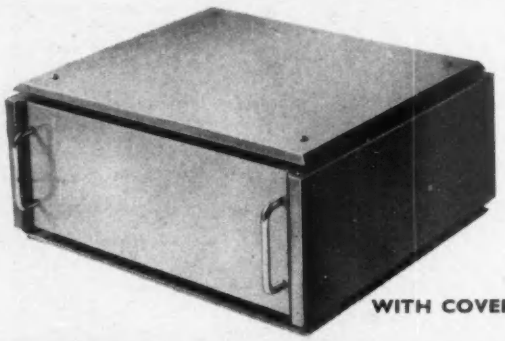

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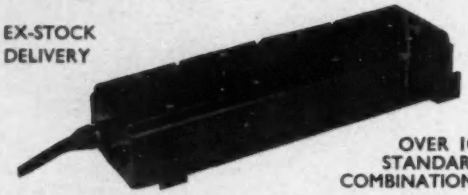

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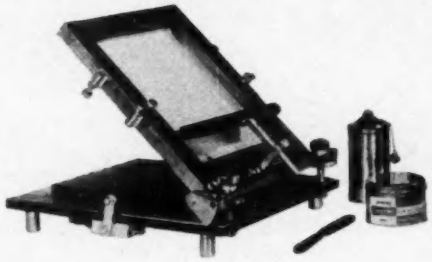

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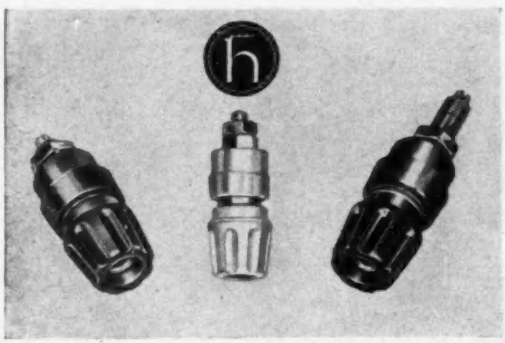

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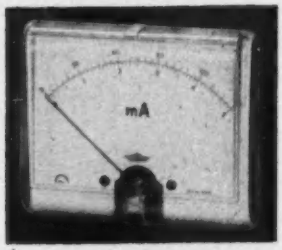

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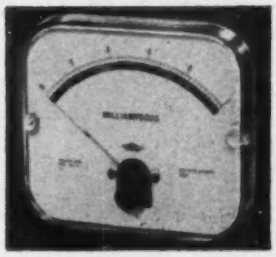

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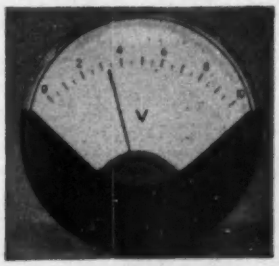

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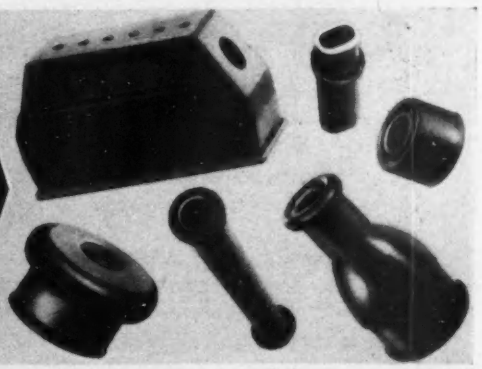

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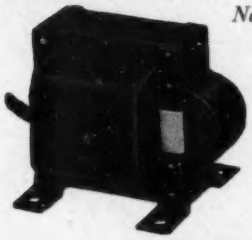

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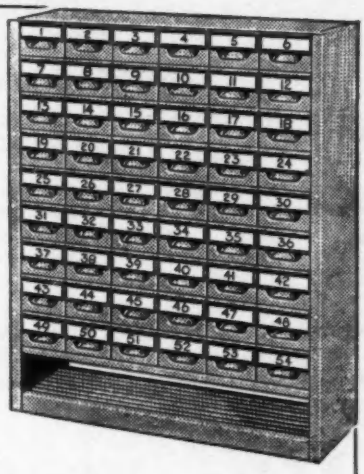

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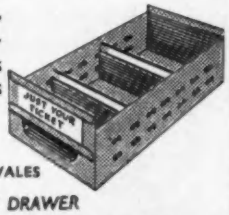

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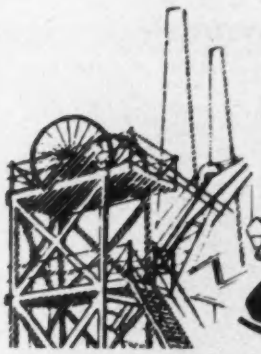

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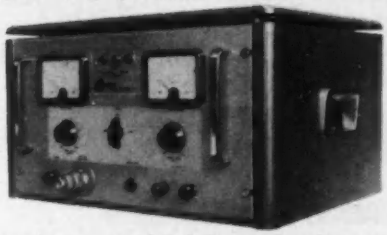

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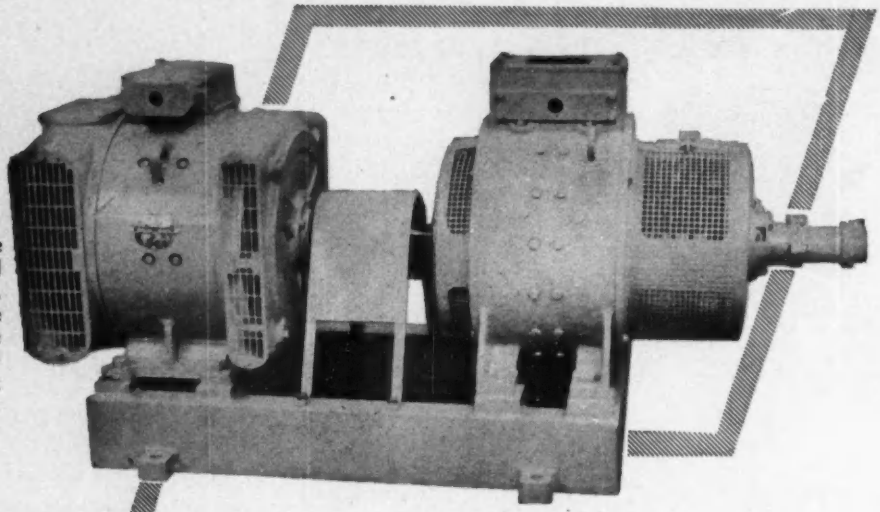

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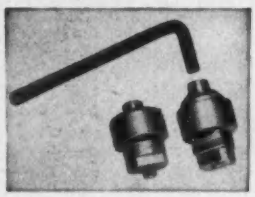

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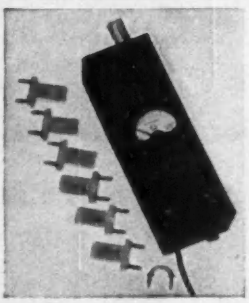

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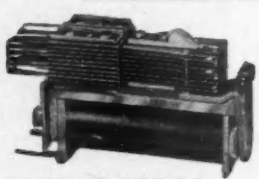

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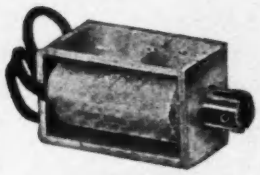

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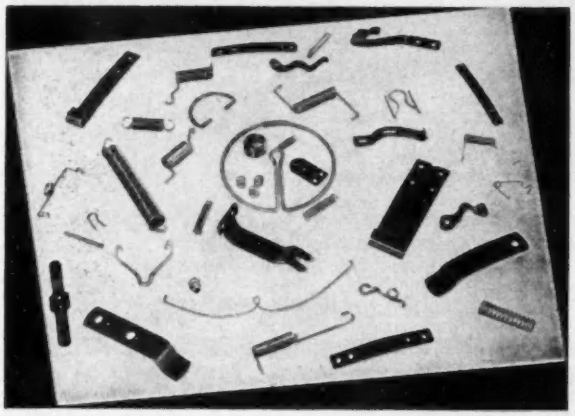

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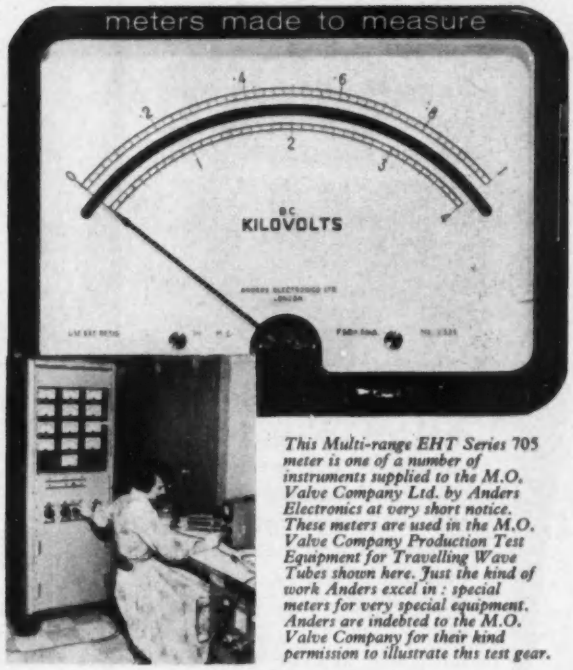

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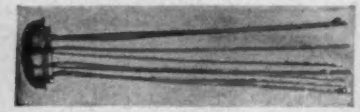

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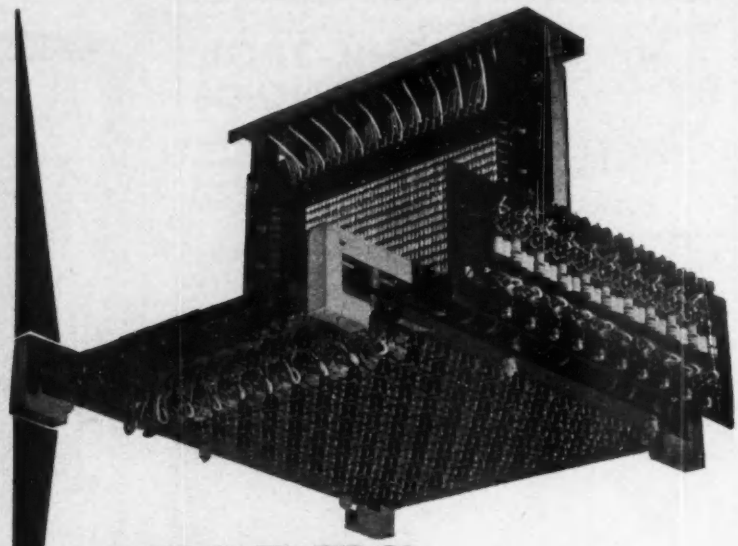

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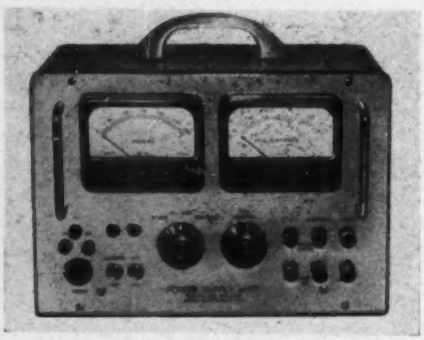

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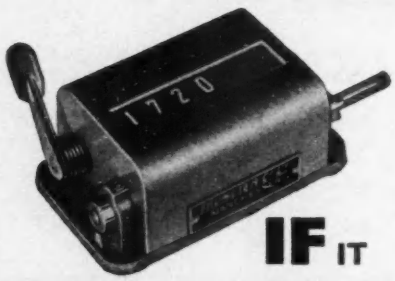

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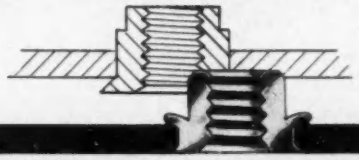

TALBOT TOOLS COMPANY LTD

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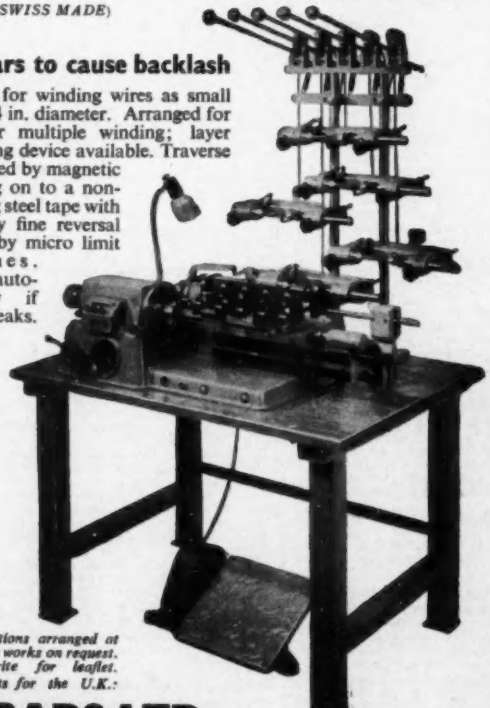
METEOR COIL WINDERS

(SWISS MADE)

No gears to cause backlash

Suitable for winding wires as small as 0.0004 in. diameter. Arranged for single or multiple winding; layer shortening device available. Traverse is obtained by magnetic clamping on to a non-reversing steel tape with extremely fine reversal settings by micro limit switches. Stops automatically if wire breaks.



Demonstrations arranged at our London works on request. Please write for leaflet. Sole Agents for the U.K.:

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EE 32 260 *for further details*

Wouldn't life be tedious?

Often at the end of a fabrication job in steel or light alloy we feel a surge of pride. Perhaps we have surveyed, designed, drawn up, made and assembled a complete installation. Or finished a quantity run of some intricate machined item. We can't always crow in public—but wouldn't life be dull without such highlights?

Have you a job to gladden our hearts?

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London Representatives: O'Neil & Co. Ltd.,
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Partially completed main frame for housing electronics equipment.

CLASSIFIED ADVERTISEMENTS

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Copy, with remittance, for the above advertisements, must be received before the 14th of the month for insertion in the following issue.

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Blocks must be mounted.

Advertisements for publication should be addressed to:
Classified Advertisement Dept., **"Electronic Engineering", 28, Essex Street, Strand, London, W.C.2.**

OFFICIAL APPOINTMENTS

CAREERS FOR RADIO TECHNICIANS in Civil Aviation. Vacancies for Radio Technicians, aged 19 or over, at Airports and Radio Stations throughout the United Kingdom, maintaining radio communication and electronic navigational aids. Fundamental knowledge of radio with some practical experience required for entry. Training given on the equipment in use. Salary approximately £670 (at 25), rising to £795. 3½ weeks' holiday with pay. Paid sick leave. Facilities to study for higher qualifications, giving good prospects of pensionable posts and promotion to grades with salary maximum £988, £1,128 and £1,388. Apply for further details to Ministry of Aviation (Est/5a), Room 755, Adelphi, John Adam Street, London, W.C.2, or any employment exchange, quoting Westminster O/N 3552. W 5106

CITY OF LEICESTER EDUCATION COMMITTEE. College of Technology and Commerce. Senior Laboratory Technician required in the School of Physics. It is desirable that applicants should be in possession of a Final City and Guilds Certificate or Higher National Certificate and have a good knowledge of electronics. Salary on scale £685 to £760 p.a. Applications, in writing, should be addressed to the Registrar at the College. W 5108

CITY OF PLYMOUTH Education Committee, Plymouth and Devonport Technical College. Principal: Eric Bailey, B.Sc., F.R.I.C., A.M.I.Chem.E. Required 1st April, or as soon as possible thereafter, Assistant Grade A in the Chemistry Department. Duties include maintenance and operation of Phillips E.M. 100 electron microscope, instruction in its use, supervision of other electronic equipment and certain teaching duties. Salary Burnham Technical Report Grade A Assistant £520×£27 10s. to £1,000. Initial salary according to qualifications and previous experience. Forms and particulars (s.a.e.) obtainable from Clerk to the Governors, to whom they should be returned as soon as possible. W 5131

D.S.I.R. REQUIRES Assistant Experimental Officer/Experimental Officer at Radio Research Station, Ditton Park, Slough, Bucks. to prepare abstracts of scientific and technical articles on radio research and development. Quals.: G.C.E. "A" level in 2 science or maths subjects. Over 22, pass degree, H.N.C. or equiv. preferably in Physics or Electrical Engineering generally expected. Exp. in radio research development, or communication, ability to read technical papers in French, German or Russian an advantage. Salary: A.E.O. £450 10s. (age 18)—£776 (age 26)—£957. E.O. £1,057-£1,296. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.104/1A. W 5119

ELECTRONICS TECHNICIAN required at the Hospital for Sick Children, Great Ormond Street, London, W.C.1, to join new medical workshop for maintenance and construction of special hospital equipment. Interesting and varied work for person with knowledge of Electronics, Electrical Engineering or Physics, or with Machine-shop practice. Possession of H.N.C. or O.N.C. or C. & G., etc., an advantage. Vacant now but can be held open for right person. Salary, £600 by £20 (2) by £25 (4)-£740 p.a. Contact Chief Technician (HOL. 9200, Ext. 235) for further information. W 5112

ELECTRONICS TECHNICIAN, experienced, for construction and servicing of specialized apparatus. O.N.C. or equivalent desirable. Salary scale, £690-£815 p.a., plus qualification allowances. Starting poiht according to age and experience. Apply, in writing, giving full details to the Administrative Assistant, Physics Department, The University, Birmingham, 13. W 5102

ENGINEERS FOR RESEARCH AND DEVELOPMENT in Government Service. Following are examples of vacancies at Scientific Officer (£738-£1,222) or Senior Scientific Officer (£1,342-£1,654) level now available: Post Office Research Station, Dollis Hill, London—research into Directional Aerial Systems suitable for long distance communications (scientific officer). National Physical Laboratory, Teddington, Middlesex—mechanical engineer to lead a small team on Hovercraft research. Practical research experience and knowledge of aerodynamics and hydrodynamics required (senior scientific officer). Admiralty Underwater Weapons Establishment, Portland, Dorset—specialist in Thermodynamics with experience (preferably at least 5 years) in Internal Combustion Engine research or Rocket Propulsion. Experience in instrumentation essential (senior scientific officer). Royal Radar Establishment, Malvern, Worcs.—light electrical engineer for research in Air Traffic Data Handling Techniques involving data extraction, digital electronic computation and data transmission (scientific officer or senior scientific officer). There are many other vacancies for Research and Development Engineers and most scientific disciplines. All posts carry a pension. Good promotion prospects. Full particulars from Civil Service Commission (Scientific Branch), 17 North Audley Street, London, W.1. W 5116

LOUGHBOROUGH COLLEGE OF TECHNOLOGY, Leicestershire, Department of Electrical Engineering. Applications are invited for a Research Fellowship for work on instrumentation and telemetering for physiological measurements on athletes. The Fellowship is tenable for up to three years at an annual value of £750 with contributory superannuation scheme. Some tutorial work or laboratory supervision may be undertaken, for which additional payment is made. Application forms may be obtained from the Academic Registrar, quoting reference 20/AT/2. W 5129

ELECTRONIC ENGINEER with knowledge of control systems required by Hydraulics Research Station (D.S.I.R.), Wallingford, Berks., for design and development of control mechanisms for hydraulic models and research equipment. Appointment as Assistant Experimental Officer or Experimental Officer according to age and experience. Quals.: Pass degree, H.N.C. or equiv. in appropriate subject. Salary ranges: A.E.O. £625 (age 22)—£776 (age 26)—£957; E.O. £1,057-£1,296. Favourable housing prospects for married officers. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.132/1A. W 5120

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, St. John Street, London, E.C.1. Department of Production Technology and Control Engineering. Post-graduate Research in Instrument and Control Engineering. Facilities are available in this department for research in instrument and control engineering leading to a higher degree of the University of London or membership of the College of Technologists (M.C.T.). Grants may be available for suitable students. Those interested are invited to apply to the Head of Department of Production Technology and Control Engineering. W 5105

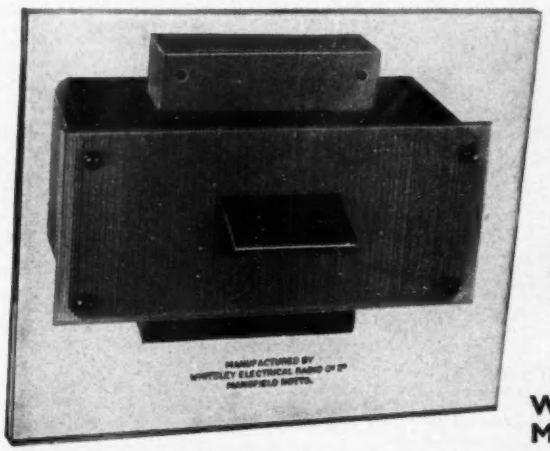
ROYAL NAVAL SCIENTIFIC SERVICE, Government Communications Headquarters require Experimental Officers and Assistant Experimental Officers at Government Communications Headquarters, Cheltenham, Glos. Duties widely distributed in field of communications research and development, including radio equipment (over wide range of frequency), terminal equipment, aerials, and radio range-finding and direction-finding systems. Propagation studies and experiments carried out. Work also includes data processing, programming and engineering, applications of electronic computing techniques and numerous problems in instrumentation. Candidates must normally be natural-born British subjects and of British parentage. E.O.'s, minimum age, 26 and normally under 31. Asst. E.O.'s at least 18 and normally under 28. Qualifications should include H.S.C. or G.C.E (with at least two ('A') Level subjects) or equivalent, or H.N.C., a University Degree or Diploma in Technology. Salaries: E.O., £1,087 to £1,356; A.E.O., £458 (at 18) to £801 (at 26 or over) to £983. Facilities for further education. Promotion prospects. Appointments unestablished, but opportunities exist for establishment. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. A.87/1A. W 5098

CLASSIFIED ADVERTISEMENTS
continued on page 206

WB electrical components

Our long experience in the design and manufacture of electrical components enables us to offer a wide range of products designed to meet with the many requirements of the electronic industry today.

This fixed frequency oscillator is constructed on a standard octal base and encapsulated in epoxy resin. Slight tuning either side of the fundamental frequency is provided by means of an adjustable core. Output: 10 mw into a 600 ohm. load. Frequency: As required within the range 700-2,000 c.p.s. sinusoidal.



On the left is an astatic wound A.F. screened line transformer with the windings encapsulated in epoxy resin. The insulation of the 'line' winding provides isolation against voltages of 30 KV RMS.

WHITELEY ELECTRICAL RADIO CO. LTD.
Mansfield, Notts. Telephone: Mansfield 1762/5

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more tubing in production

VITREOSIL* pure fused quartz

New production techniques are now speeding up deliveries of Vitreosil Fused Quartz Tubing—the most transparent manufactured material.

It is impermeable, can be used repeatedly up to 1050°C, is inert to all acids except hydrofluoric, and has high light transmittance in the U.V. and I.R. spectra.

There are a wide range of diameters and two wall thicknesses—thin and normal.

Full details on request.

all BRITISH ...the BEST

THE THERMAL SYNDICATE LTD.

P.O. Box No. 6, WALLSEND, NORTHUMBERLAND *Tel: Wallsend 62-3242/3*
LONDON: 9 BERKELEY STREET, W.1. *Tel: Hyde Park 1711/2*

*Registered Trade Mark

OFFICIAL APPOINTMENTS (Cont'd.)

ROYAL NAVAL SCIENTIFIC SERVICE Admiralty require Senior Scientific Officers/Scientific Officers at an Underwater Weapons Establishment, Portland, Dorset (Ref. C69/1A). (1) Mechanical Engineer, specialised in thermodynamics with experience in internal combustion engine research and/or rocket propulsion field. Minimum 5 years' experience in either expected. Some experience in appropriate instrumentation essential with design study work on components of rocket systems or other propulsion gear. Turbine design experience advantageous. (2) Mechanical Engineer with bias for one or more of: (i) hydraulically operated mechanisms, including servo-control; (ii) mechanics of machines (theory and practice); (iii) hydro- (or aero-) dynamics of fairly elementary character. (3) Hydrodynamicist (or Aeronautical Engineer), with some years' experience for work on torpedo dynamics. (4) Mechanical Engineers (Servo-mechanisms, gyro design and develop), Electronic Engineers (Electronics/Design), Mathematicians (Operational research and theoretical physics), Physicist (acoustics). B: Government Communications H.Q., Cheltenham (Ref. A43/1A). Physicists (Telecommunications), Mathematicians, Electronic Engineers (Electronics/Radar): Telecommunications and Radio). C: Naval Construction Research Establishment, Dumfermline (Ref. C70/1A). Structural and Mechanical Engineers, Mathematical Physicists and Mathematicians, for teams engaged on research problems of structural strength, effects of conventional and nuclear weapons and development of new structural materials. Excellent opportunities and good prospects for promotion. D: Admiralty Compass Observatory, Slough (Ref. D47/1A) Electrical or Mechanical Engineers or Physicists interested in gyro-techniques, servo-mechanisms or electronics. Qualifications for all posts: 1st or 2nd Class Honours Degree or equivalent in appropriate subject. Must normally be natural born British subjects of natural born British parents. S.S.O.'s must have had minimum 3 years' post-graduate experience and be not less than 26 years of age. Salaries: (A) S.S.O., £1,302-£1,604; S.O., £717-£1,186. (B, C, D) S.S.O., £1,342-£1,654; S.O., £738-£1,222. Appointments unestablished (with F.S.S.U. benefits) but opportunities for those between 21 and 32 to compete for established posts. Forms from Ministry of Labour, Technical & Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate reference and post. W 5080

ROYAL TECHNICAL COLLEGE, SALFORD. Department of Electrical Engineering. Continued expansion of this College of Advanced Technology results in a limited number of vacancies for academic staff at all levels; salaries range from £700 to £2,100 p.a., or possibly higher in special cases. Applicants should be Graduate Electrical Engineers or Physicists. Considerable importance will be attached to proven ability in research, and commencing salaries will take account of past achievement. Lecturing hours, and equipment available, are such that a genuine opportunity exists for original work. Some posts may be primarily research appointments. Further particulars and forms of application may be obtained from the Registrar, Royal Technical College, Salford, 5, Lancs. (Please quote Ref. E.E.), to whom applications should be returned by 14 April, 1961. W 5109

TECHNICIAN FOR ELECTRONICS MEASURING and ancillary equipment for bubble chamber data analysis group. Salary scale, £690-£815 p.a. Additional payments for qualifications. Experience in punched tape data recording desirable. Apply, in writing, giving full details to the Administrative Assistant, Physics Department, The University, Birmingham, 15. W 5103

THE UNIVERSITY OF SHEFFIELD Department of Electrical Engineering. Applications are invited for two Research Fellowships in the Department of Electrical Engineering under Professor A. L. Cullen, in the field of millimetre wave techniques. The research programme involves the study of new methods of generating millimetre waves and the development of measuring techniques. Applicants should preferably have a Ph.D. degree in Engineering or Physics, or equivalent research experience. The salary will be determined in relation to qualifications and experience in the range of £800 to £1,350. Applications should be sent to The Registrar, The University, Sheffield, 10. W 5121

UNIVERSITY OF NOTTINGHAM. Applications are invited for the appointment of Lecturer in Electrical Engineering. Candidates should preferably, though not necessarily, have had some industrial experience and be interested in teaching and research in one or more of the following fields: Electrical Machines; Electrical Power; Computers; Electronics. Salary scale, £1,050-£1,850. Initial salary according to qualifications and experience, with membership of the Universities' Superannuation Scheme and children's allowance. Conditions of appointment and form of application, to be returned by 5 May, 1961, from the Registrar. W 5128

UNIVERSITY OF ABERDEEN: Applications are invited from suitably qualified persons to operate (and maintain) an electron microscope to be installed shortly for scientific and medical departments within the University. Experience of operation and maintenance of an electron microscope essential and knowledge of electronics and high vacuum technique an advantage. Salary on scale £690–£815 per annum, plus appropriate supplementation for qualifications. Applications, with names of two referees, to Secretary to the University, Marischal College, Aberdeen, by 10th April, 1961. W 5132

UNIVERSITY OF BELFAST. Research Technician required as a general Research Assistant in connection with fluid dynamics, structures, soil mechanics, etc. The work will be mainly concerned with electronic equipment and will involve design, construction and development. The candidate should, therefore, have a suitable theoretical and practical background but a degree is not essential. Initial salary range, £800-£1,000 according to qualifications. Applications to Professor A. H. Naylor, Civil Engineering Department, by 15 May, 1961. W 5124

SITUATIONS VACANT

ASSISTANT TO THE CHIEF ENGINEER. Painton & Co. Ltd., manufacturers of high-quality components for the Electronics Industry, are expanding their activities and wish to appoint an Assistant to the Chief Engineer. Applicants must be graduates in Physics or Electrical Engineering, have experience in the design and development of Electronic Components and be able to carry executive authority. This is a staff appointment with Superannuation Scheme. Applications to the Personnel Officer, Kingsthorpe, Northampton. W 5125

ASSOCIATED-REDIFFUSION LIMITED is prepared to offer young men with high grade electronic qualifications an opportunity to specialise in television broadcasting engineering as Technical Assistants, at a salary of £891 per annum, for a training period of up to one year, after which they will be absorbed into engineering vacancies at salaries from £1,091 per annum. Applications stating age, qualifications and experience should be addressed: Manager Engineering, Associated-Rediffusion Limited, Television House, Kingsway, London, W.C.2. W 5123

ASSOCIATED ELECTRICAL INDUSTRIES LTD., Electronic Apparatus Division, Trafford Park, Manchester, 17. Testers urgently required for interesting work on Ground Radar, Servo-Control and Computer systems. Technical qualifications an advantage. There are excellent opportunities available for suitable applicants. Why not write in now for application form and conditions, to The Employment Supervisor, A.E.I. (Manchester) Ltd., Trafford Park, Manchester, 17. W 5111

ELECTRICAL DEVELOPMENT ENGINEER required for a Company situated in N.W. London, for work on design and development of special purpose equipment, machine tool control systems and small electrical machines and appliances. Minimum qualification H.N.C. or equivalent. Practical experience in this field an advantage. Salary £1,100. Box No. W 5130.

ELESTA AG, SWITZERLAND, manufacturers of cold cathode decade counters, relay tubes and electronic controls, require British Electronic Engineer with about three years' experience, some sales potential and good knowledge of German. Position will entail 1-2 years' training in Switzerland with a view to acting as technical and sales consultant to industrial clients in Britain. Applicants should submit in confidence, full details of qualifications, experience, references, photograph and salary required, to Britec Ltd., 17 Charing Cross Road, London, W.C.2. W 5097

DAVY AND UNITED ENGINEERING COMPANY LIMITED invite men with either a Degree in Electrical Engineering of the H.N.C. (Electrical) to apply for the position of Electronic Engineer in the Research and Development Department. Previous experience in solid state circuitry associated with instrumentation and control essential. Familiarity with digital techniques an advantage. Salary commensurate with qualifications and experience. Contributory pension scheme and comprehensive amentities. Applications, with details of age, previous experience and qualifications, should be addressed to The Staff Personnel Officer, Davy and United Engineering Company Limited, Darnall Works, Sheffield, 9. W 5101

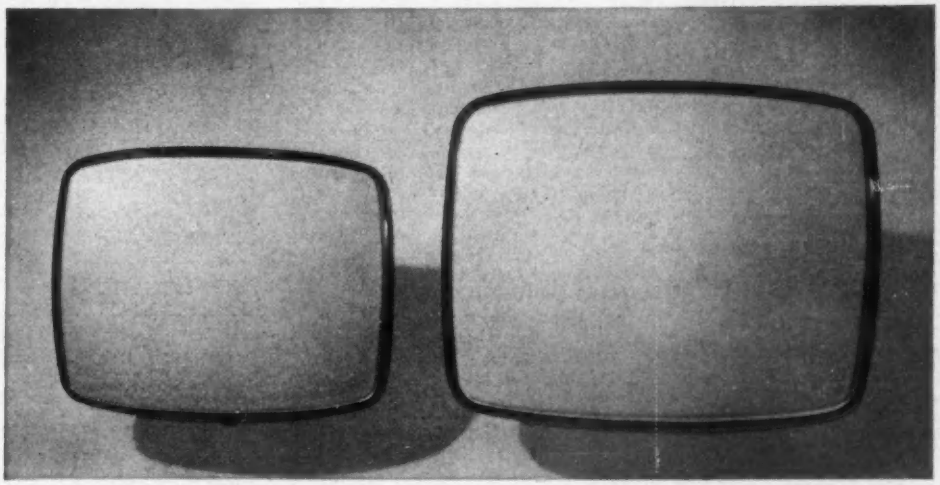
DAVY AND UNITED ENGINEERING COMPANY LIMITED require a Research Technician. Previous experience of electronics and Service Radar preferable and Engineering background an advantage. Good conditions. Contributory pension scheme, sports facilities. Apply in writing with full details to: Personnel Department, Davy and United Engineering Company Limited, Darnall Works, Sheffield 9. W 5122

ELECTRONIC ENGINEER. There is a vacancy in a small Research and Development Unit of a well-known Electrical Engineering Organization for a man aged 25-30 years, capable of work on his own initiative on the design and development of circuits for various types of process control and other allied equipment. A knowledge of transistors and their uses is desirable and candidates should possess a Degree or Higher National Certificate in Physics or Engineering, together with not less than two years' experience of work in a similar field. A salary of not less than £850 is envisaged and this may be more according to qualifications and experience, together with contributory Pension Scheme and free Life Assurance. Applications, in writing, to Mr. D. A. Richards, The Plessey Co. Ltd., Forsyth Road, Sheerwater Estate, Woking, Surrey. W 5115

ELECTRONIC PROJECT ENGINEER required for interesting work in small unit of large Group. V.H.F. and transistor experience coupled with ability to rapidly finalise projects is a definite asset. Good salary and working conditions. H.N.C. normal minimum qualifications. Communications (Air) Ltd., Half Moon Street, Bagshot, Surrey. Telephone: 3085. W 358

CLASSIFIED ADVERTISEMENTS
continued on page 208

NEW 19" AND 23" TELEVISION CATHODE RAY TUBES



EDISWAN MAZDA TYPES CME1901 AND CME2301

The CME1901 and CME2301 are, respectively, 19in. and 23in. cathode ray tubes using magnetic deflection and electrostatic focus. The diagonal deflection angle of CME1901 is 114° and that of CME2301 is 110°. The shape of these tubes differs from the shape of conventional 110° tubes in that the face plates are more nearly rectangular. In addition the radii of curvature of the faces of the 19in. and 23in. tubes are greater than those of the 17in. and 21in. tubes. These changes result in a more pleasing presentation of the picture.

The external shape of the glass in the deflection region of these tubes is identical to that of conventional 110° tubes, enabling coils with conventional 110° internal mechanical contours to be used.

With equal values of final anode voltage, beam deflection in the CME1901 and CME2301 can be carried out with no more power consumption than in the CME1703 and CME2101.

GENERAL DETAILS

Rectangular face	Aluminised screen
Electrostatic focus	Silver activated phosphor
Magnetic deflection	Grey glass
Straight gun — non ion trap	External conductive coating
Heater for use in series chain	

Heater Current (amps)	I_h	0.3
Heater Voltage (volts)	V_h	12.6

TENTATIVE RATINGS AND DATA

Design Centre Ratings		**CME1901**	**CME2301**
Maximum Second and Fourth Anode Voltage (kV)	$V_{a2,a4\,(max)}$	17	17
Minimum Second and Fourth Anode Voltage (kV)	$V_{a2,a4\,(min)}$	14	15
Maximum Third Anode Voltage (volts)	$V_{a3\,(max)}$	±700	±700
Maximum First Anode Voltage (volts)	$V_{a1\,(max)}$	500	500
Maximum Heater to Cathode Voltage—Heater Negative d.c. (volts)	$V_{h\text{-}k\,(max)}$	180	180

Inter-electrode Capacitances (pF)		**CME1901**	**CME2301**
Cathode to All*	$C_{k\text{-}all}$	5	5
Grid to All*	$C_{g\text{-}all}$	8	8
Final Anode to External Conductive Coating (approx.)	$C_{a2,\,a4\text{-}M}$	1500	2000

*Inter-electrode capacitances including AEI "Clix" B8H holder VH68/81 (8 pin).

TYPICAL OPERATION

		CME1901	**CME2301**
Second and Fourth Anode Voltage (kV)	$V_{a2,\,a4}$	16	16-17
First Anode Voltage (volts)	V_{a1}	450	450
Third Anode Voltage for Focus-Mean (volts)	$V_{a3\,(av)}$	180	180
Grid Bias for cut-off of Raster (volts)		38 to 72	38 to 72
Average Peak to Peak Modulating Voltage for Modulation up to 350μA (volts)		34.5	34.5

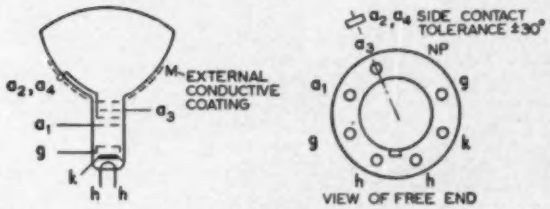
Note: All voltages given with respect to the cathode.

Maximum Dimensions (mm)	**CME1901**	**CME2301**
Overall Length	322	386
Face Diagonal	476†	598†
Face Width	420†	524†
Face Height	342†	422†
Neck Diameter	29.4	29.4

†The maximum dimension at the face seal may be 3.5 mm larger than this dimension but at any point around the seal the bulge will not protrude more than 2 mm.

Tube Weight (lb.)	**CME1901**	**CME2301**
Nett (approx.)	13.5	27

Side Contact: CT8 (Cavity) **Base:** B8H



Associated Electrical Industries Ltd
Radio and Electronic Components Division
Technical Service Department
155 Charing Cross Road, London, W.C.2
Tel: GERrard 9797 Grams: Sieswan Westcent London

EDISWAN
MAZDA

TA16/106/8300

SITUATIONS VACANT (Cont'd.)

ELECTRONIC ENGINEER. Interesting, varied work on scientific instruments. Small, rapidly expanding company provides friendly and informal conditions with good opportunities for advancement. Essential qualification: a thorough understanding of electronic valve circuitry at d.c. and low frequencies, both theoretical aspects and practical application. Experience of transistors, printed circuits and/or magnetic amplifiers an advantage. State fully career details and salary required to Technical Director, Shandon Scientific Co. Ltd., 6 Cromwell Place, S.W.7. W 5052

JUNIOR ELECTRONIC DEVELOPMENT ENGINEER. Familiar—general industrial electronics circuitry—with some knowledge of chassis and case design, etc. £650–£800 p.a. Staff position, pension scheme, sick club. Write: Grundy & Partners Ltd., 3, The Causeway, Teddington, Middx. W 5135

LABORATORY SENIOR TECHNICIAN (Physics) Queen Mary College (University of London), Mile End Road, E.1. Salary placing on scale £690 × £25—£815 p.a. according to ability. London Weighting up to £45 and possible qualifications supplement of £30 or £50. Pension Scheme. Five day week. Four weeks annual leave. The person appointed will if found suitable be in charge of the electronics workshop. Letters only to Registrar (PST), stating age, full details experience and present work. W 5134

LABORATORY TECHNICIAN (PHYSICS) Queen Mary College (University of London), Mile End Road, E.1. Salary according to ability on scale £490 p.a. by 20/25 to possible £675. Plus London Weighting £30 to £45 according to age, and possible qualification supplement of £30. Pension Scheme. Five day week. Four weeks annual leave. Electronics experience desirable. The person appointed will work on a D.S.I.R. supported project dealing with extreme infra red spectroscopy. Appointment in first instance for about 2½ years with possibility of permanency. Letters only to Registrar (PT), stating age, full details experience and present work. W 5133

LOUIS NEWMARK LIMITED, leading company in the design of auto pilots for helicopters are expanding their facilities at their Development Laboratories at Croydon and have the following vacancies to be filled immediately. Engineers and Assistant Engineers with degree or H.N.C. and experience in the field of light electrical engineering, electronics, electro mechanical devices or semi conductors, to work on the development, installation and flight testing of automatic pilots. Salary commensurate with experience. Pension Scheme. Apply in writing, giving full particulars, to: Personnel Officer, Louis Newmark Ltd., Prefect Works, Purley Way, Croydon, Surrey. W 351

MINISTRY OF AVIATION, Welwyn Garden City, requires Technician to assist in supervision of inspection of airborne and ground radar communication and special electronic equipment at contractors' works. Qualifications, recognized Engineering apprenticeship or equivalent training. O.N.C., C. & G. Final Certificates or equivalent. Sound technical knowledge of electronics. Experience of inspection of electronic equipment an advantage. Salary, £961-£1,098. Technical College courses sponsored for suitable candidates. Good prospects for promotion and pension. Forms from Manager (PE883), Ministry of Labour, Professional and Executive Register, Atlantic House, Farringdon Street, London, E.C.4. W 5113

OVERSEAS. Electronic Technicians are required by an Oil Exploration Company with Headquarters in the U.K. Men should be single on joining. Work will include the maintaining and operating of field equipment often under conditions of desert, jungle, and swamp. The equivalent of an H.N.C., with practical experience in electronics, is essential. Tours overseas are of up to two years followed by home leave. Write with full particulars, covering any time spent in the Forces, to Box No. W 356.

OPERATOR is required for a Geophysical Playback Centre, incorporating multi-channel magnetic recorder/reproducers. Applicants should have H.N.C. with electronics, or exceptional practical experience; geophysical, field or playback experience, would be an advantage. Hayes-Orpington area. Box Number W 5127.

RESEARCH AND DEVELOPMENT. Due to internal promotions there are vacancies for Engineers and Assistants. in our Research and Development Departments, which are concerned with fundamental problems of temperature measurement and with the development, prototype manufacture, and approval testing of components and systems for Aircraft and Industrial Equipment, principally Electro-Thermal devices. H.N.C. with some experience of industrial Research and Development, or experimental engineering work. Experience of transistor circuitry would be an advantage. The diverse nature of the mechanical, electrical and electronic problems of these departments will appeal to applicants with wide interest and a versatile approach. Applications to Personnel Manager, Wilkinson Sword Limited, Colnbrook, nr. Slough, Bucks (Tel.: Colnbrook 2345). W 5114

SENIOR DEVELOPMENT ENGINEER required for work on laboratory and industrial instruments for control systems. Applicants should hold a Degree, Dip.-Tech., or H.N.D. with a sound academic knowledge of control systems and a minimum of 3 years' experience in electronic instrumentation, servo-mechanisms or analogue computing units. Experience in transistor circuit design would be an advantage. The position will involve working in collaboration with consultants and developing basic ideas for instruments to the production stage with the assistance of a small team of technicians. The salary will be about £1,500 p.a. The working location is Crowborough, Sussex. The company is a young one but intends to grow. Apply to the Managing Director, Feedback Ltd., Crowborough, Sussex. W 5126

W. H. ALLEN SONS & CO. LTD. require a Senior Servomechanisms Engineer. Applicants must have a sound knowledge of servo theory and be experienced in the design of circuitry using transistors. At least 5 years' experience, a degree or good H.N.C. are the minimum qualifications. Age 28-45. Good prospects are open to the right man. Write for application form and conditions of service, etc., to: The Personnel Manager (Ref. 1007/3/1), Queens Engineering Works, Bedford. W 5117

YOUNG ELECTRONICS ENGINEER required by well-known London firm of Chartered Patent Agents with expanding electrical practice. Should have Honours Degree, be aged 25 or under and be prepared to study for qualifications as Chartered Patent Agent. Man graduating this year might be suitable. Write, giving full particulars as to age, qualifications, etc., Box No. G4505 c/o Whites, 72 Fleet Street, London, E.C.4 W 5095

SERVICE ENGINEER required by Northern Electronics Instrument Manufacturer. Interesting work on all types of electronic testing instruments. Staff Pension Scheme and prospects of promotion. Applicants should state experience, qualifications, age and present salary. Box No. W 5107.

SITUATIONS WANTED

GRADUATE IN MATHEMATICS and Physics (26 years of age) with 2 years' Industrial experience as a Mathematician and 2½ years as an Auto-pilot Servo-Engineer, wishing to widen his experience in the field of Automatic Control, desires progressive post with large or small organization. Analogue techniques have been sole experience to date, but is interested also in digital techniques. Box No. W 2026.

EDUCATIONAL

CITY AND GUILDS (Electrical, etc.) on "NO PASS—NO FEE" terms. Over 95 per cent successes. For details of modern courses in all branches of Electrical Engineering, Applied Electronics, Automation, etc., send for our 148-page handbook —FREE and post free. B.I.E.T. (Dept. 337c), 29 Wright's Lane, London, W.8. W 316

LEARN RADIO AND ELECTRONICS the New Practical Way! Very latest system of experimenting with and building radio apparatus—'as you learn'. Free Brochure from Dept. EE10, Radiostructor, 40 Russell Street, Reading, Berks. W 353

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, St. John Street, London, E.C.1. Department of Productiou Technology and Control Engineering. Post-graduate Diploma Course in Industrial Automatic Control. Eight places are offered in the next Post-graduate Diploma Course in Automatic Control which will start on 2 October, 1961. The course is full time and lasts one academic year. Academic qualification for entry is a Degree or Diploma in Technology in Science, Engineering or Matnematics, or an equivalen Science, Engineering or Mathematics, or an equivalent qualification. Some industrial experience is also required. On successful completion of the course students are awarded the Post-graduate Diploma of Northampton College, London (D.N.C.L.). Grants may be available for suitable students. Those interested are invited to apply to the Head of Department of Production Technology and Control Engineering. W 5104

TV. AND RADIO—A.M.Brit.I.R.E., City & Guilds, R.T.E.B. Certificate, etc., on "NO PASS—NO FEE" terms. Over 95 per cent successes. For details of Examination and Home Training Courses (including practical apparatus) in all branches of Radio, T.V. and Electronics, write for 148-page handbook—Free. B.I.E.T. (Dept. 337H), 29 Wright's Lane, London, W.8. W 187

CLASSIFIED ADVERTISEMENTS
continued on page 210

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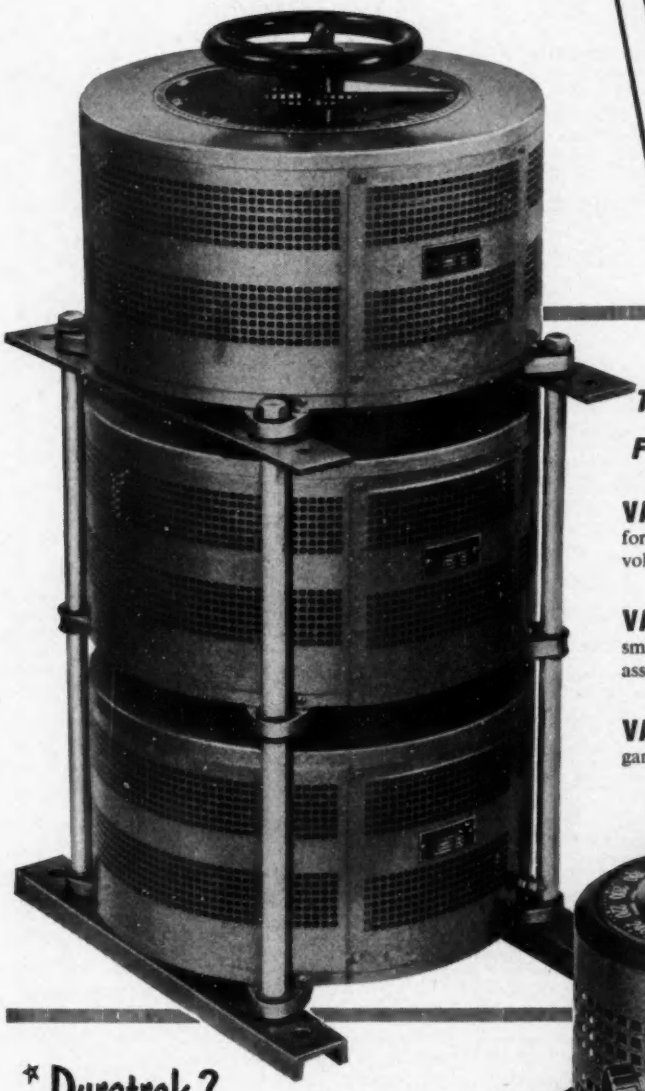
This 3-gang assembly, Type 50-BMG3, will control 22·5 kVA, 3-phase or single-phase according to connection. Larger assemblies can be made.



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VARIACS are available open or covered, as single units or ganged assemblies, for manual operation or motor-driven.

The range includes portable, metalclad and oil-immersed models, dual-output types, high-frequency types and many 'specials'.
Write for complete information.

This small Variac, Type V-5HMTF, provides an output of 0-270 V, 2 A, from 240 V 50 c/s mains. A still smaller model, Type V-3H is rated at 1 A.

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Duratrak (Regd. Trademark) — a patented* feature exclusive to Variac — is a special plated contact surface giving longer life, increased overload and surge capacity and maximum economy in maintenance. Duratrak is now standard on all models except Series 50.

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CL59/1B

EDUCATIONAL (Cont'd.)

UNIVERSITY OF CAMBRIDGE. Department of Engineering Postgraduate Course in Control Engineering. The 1961-62 Postgraduate Course in Control Engineering will begin on 9 October, 1961, and will last approximately nine months. This course has been established in order to meet the needs of industry for men trained to a high standard in the theoretical principles and practical application of automatic control and to afford opportunity for study of advanced techniques and modern development in the general field of Control Engineer, sometimes called "Systems Engineering". The number of students will be limited and applications must reach the Secretary of the Department not later than 31 May, 1961. Candidates should hold a Degree in Engineering or a suitable alternative qualification and have had at least 2 years' practical training and experience. They may be required to attend for interview in Cambridge. Further details and forms of application for admission may be obtained from the Secretary, Cambridge University Department of Engineering, Trumpington Street, Cambridge. W 5110

INDUSTRIAL PREMISES

FARNHAM, SURREY. Excellent modern brick-built light industrial premises of 1,200 super feet, on 2 floors, with main water, elect. (3 phase), drainage and (W.C.), together with a Modern Bungalow (1957) with sitting room 16 ft 6 in. × 13 ft., sliding doors to dining room 13 ft. × 12 ft., fitted kitchen, 3 bedrooms, bathroom and separate W.C., 3 garages and extra bungalow plot with planning consent for one. £7,950 Freehold. W 5118

CAPACITY AVAILABLE

CAVE, SMITH & COMPANY LTD., have capacity available for assembly or sub-assembly of all electronic equipment, cable forms, looms and harnesses. Contract, sub-contract, short runs or regular production. Delivery promises kept. All inquiries to Union Street, Hereford 6063. W 2021

DON'T FORGET Precision Units Ltd., Seacrest Works, Church Road, Parkstone (1664), Dorset, for Machine Engraved labels in plastic and metal. Keen prices. Reliable delivery. First Class productions. W 4024

ELECTRONIC ASSEMBLY & WIRING capacity available backed by full machine shop facilities. D.E.I. approved. G. H. Garland & Company Limited, 101-105 Nibthwaite Road, Harrow, Middlesex. Harrow 3536. W 4025

IMMEDIATE CAPACITY AVAILABLE for Coil Winding. Specialists in Wave Winding. Wiring of V.H.F. and Electronic Equipment. Small batch or production runs. High standard of work. Electronic Service, 282 Sussex Way, N.19. W 2029

USE OUR Toroidal Winding Machines. Capacity available for winding Cores, having finished i/d of 0.055 in. up to 24 in. o/d with 6 in. maximum height. Experienced engineers, skilled operators, are available to give efficient service and speedy delivery. Inquiries: Production Engineer, Toroid Division, Aveley Electric Limited, South Ockendon, Essex (SOO 3444). W 5070

AGENCIES

WANT A LONDON SHOWROOM? Technical Representative with London showroom, installation and service facilities, requires agency for electro-mechanical equipment. Box No. W 2028.

PATENTS

PATENT No. 710,471, entitled "Improved Method of and Means for Making Electrical Connections", is for sale or licence. For details apply to Chatwin & Company, Chartered Patent Agents, 253 Gray's Inn Road, London, W.C.1. W 5094

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ENVIRONMENT CABINETS. Why use antiquated methods to obtain Low Temperatures when they can be obtained by the flick of a switch. Used for Metal Treatment, Research, Testing, Storage and Preservation. Will Lec Cabinet Temperature ranges from Plus 100 C to Minus 100 C cover your requirement ? Write for further details to—Low Temperature Division, Lec Refrigeration Limited, Bognor Regis, Sussex. W 5029

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METALWORK. All types cabinets, chassis, racks, etc., to your own specifications. Philpott's Metalworks Ltd., Chapman Street, Loughborough. W 341

TRANSFORMERS DESIGNED AND MANUFACTURED Prototypes or batch productions of all types up to 3 K.VA. Prompt delivery. Suppliers to BBC, ITA, Universities and leading Industrial Concerns. Est. 1922. Phone: SHI : 2483. Forrest Transformers Ltd., Shirley, Solihull, Warwickshire. Telephone SHIrley 2483. W 350

TECHNICAL TRANSLATIONS—TRADUCTIONS TECHNIQUES. Français-anglais. P. J. Arthern, 34 Oxford Road, Carshalton, Surrey, England. W 2027

FOR SALE

LARGE STOCK of various surplus, electrical insulating materials in sheet, strip, tube, bar and rod form, plus a big quantity of 12 in. by 8 in. pieces of Paxolin sheet from $\frac{1}{8}$ in. up to $\frac{1}{4}$ in. thick; also large quantity of light, screened, cable in various sizes. Woodfield & Turner, Ltd., Burnley (Tel. 78134). W 5018

FOR SALE: One Semi-Automatic Temperature Coefficient of Capacitance Test Apparatus Mark II Designed by Signals Research Laboratory for high speed testing of capacitors. Full details and reduced price from L. Solloman Ltd., Beaufort Street, Manchester, 3. Telephone: BLA 4571. W 5032

50,000 PRECISION INSTRUMENT GEARS of all types from stock. (Now including spiral bevels.) Write for fully comprehensive catalogue. The Davall Gear Company Limited, Potters Bar, Middlesex (Telephone No. Potters Bar 2382). W 357

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OPPORTUNITIES IN PRODUCTION ENGINEERING

The expanding programme of the Company in the important new field of

SEMI-CONDUCTOR DEVICES

gives rise to vacancies for

QUALIFIED ENGINEERS AND PHYSICISTS

as follows:—

1. **SENIOR PRODUCTION ENGINEERS** with direct experience of the production of semi-conductor devices.
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3. **TECHNICAL PROCESS ENGINEERS** of graduate status for the technical control of production and for the development of production processes.

Application should be made in writing to **T. J. Lunt, Staff Manager, Ferranti Limited, Hollinwood, Lancs,** giving in the first instance brief details of qualifications and experience. **Reference JRP 1-3 should please be quoted.**

Mullard

MULLARD SOUTHAMPTON WORKS

There is a vacancy for an

ENGINEER

to take charge of a section of the Quality Laboratory dealing with all aspects of quality control, measurements, life testing, etc., on rectifiers and thyristors.

The job entails responsibility for quality of the products and includes liaison with Technical/Commercial Departments and Applications Laboratories. The post calls for a minimum qualification of a University Degree in Science or Electrical Engineering or Graduateship of the I.E.E. Experience of the applications of electronics, preferably in the control field, is required and experience in the power field would be useful.

Candidates interested in joining the Mullard Semi-Conductor Centre in this capacity are requested to apply in writing to the Plant Personnel Officer, Mullard Southampton Works, Millbrook Industrial Estate, Southampton quoting the reference C.24.

"Mullard" is the Trade Mark of Mullard Ltd.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

PRODUCTION GROUP

INSTRUMENT MECHANICS

Windscale and Calder Works, and Chapelcross Works require experienced men with knowledge of electronic equipment and/or industrial instrumentation for fault diagnosis, repair and calibration of a wide range of instruments used in nuclear reactors, radiation laboratories and chemical plant. This interesting work involves the maintenance of instruments using pulse techniques, wide band low noise amplifiers, pulse amplitude analysers, counting circuits, television, and industrial instruments used for the measurement of pressure, temperature and flow.

Men with Services, Industrial or Commercial background of radar, radio, television, industrial or aircraft instruments are invited to write for further information. Training Courses in Specialised Techniques are provided for successful applicants having suitable instrumentation background. Married men living beyond daily travelling distance will be eligible for housing. A lodging allowance is payable whilst waiting for housing. Working conditions and promotion prospects are good.

Applications to:—

Works Labour Manager, Windscale and Calder Works, Sellafield, Seascale, Cumberland.

or

Works Labour Manager, Chapelcross Works, Annan, Dumfriesshire, Scotland.

United Kingdom Atomic Energy Authority and National Institute for Research in Nuclear Science

INSTRUMENTATION AND DATA HANDLING

for

NUCLEAR PHYSICS RESEARCH at HARWELL

Scientists are required by the U.K.A.E.A. and by the National Institute for Research in Nuclear Science for the study of advanced instrumentation problems associated with the use of large particle-accelerators in Nuclear Research at the Atomic Energy Research Establishment and the Rutherford Laboratory, Harwell. They will collaborate closely with scientists conducting experiments with such machines as the Cyclotron, the Tandem van-de-Graaff, the Proton Linear Accelerator, the Neutron Booster and the 7GeV Accelerator now under construction. There is a wide variety of problems to be tackled, such as the use of scintillating materials or semi-conductors to record rare nuclear disintegrations or the paths of nuclear particles, high-speed information storage and specialised data handling for the analysis of nuclear events, and the measurement of time intervals of the order of 1 millimicro-second.

Preference will be given to candidates with experience in some of the above fields or in experimental Nuclear Physics, but all applicants should posess first or good second class honours degree, preferably in Physics or Electrical Engineering.

Salary will be according to experience in the following ranges

Principal Scientific Officer:	£1,840—£2,590 p.a.
Senior Scientific Officer:	£1,440—£1,770 p.a.
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* For 3 years post-graduate experience starting salary will be at least £1,010 per annum. Housing and contributory pension schemes.

Send POSTCARD for details to **Personnel Manager (1888/42) U.K.A.E.A. A.E.R.E., Harwell, Didcot, Berks.**

ELLIOTT

High Voltage Tube Engineers

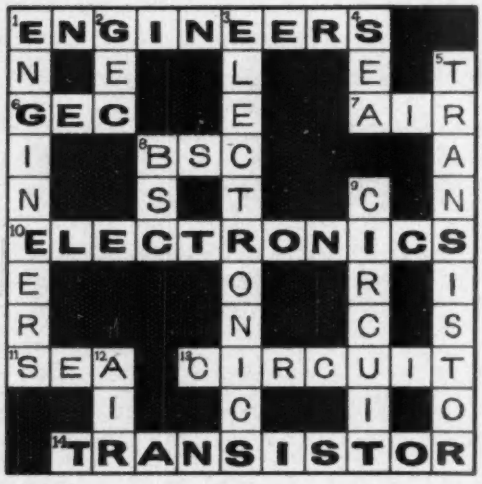
Vacancies exist in our High Voltage Tube Division for Qualified High Voltage Tube Engineers with development and manufacturing experience of *X*-ray tubes, thyratrons, rectifiers or transmitting valves, for interesting development work on new types of high voltage electron tubes.

Applications should be addressed to:

The Personnel Manager (Ref. 325)

ELLIOTT BROTHERS (LONDON) LIMITED

Elstree Way, Borehamwood, Herts.



ACROSS

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We shall be pleased to arrange informal interviews at weekends if desired. Please write in confidence to the Personnel Officer, or phone Portsmouth 62271.

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THE AIRPORT, PORTSMOUTH.

RANK PRECISION INDUSTRIES LIMITED

Central Research Laboratories

have a vacancy for a

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for logical and circuit design associated with digital computer printing systems. Initially the work will be individual systems design associated with the Xeronic high-speed computer printer, but later will include work on other printing devices.

Applicants should have several years design experience and be able to work without detailed supervision.

A staff pension scheme is in operation and salaries are reviewed annually.

Please apply in writing, giving details of qualifications and career so far, to:—

Mr. K. G. Huntley, *Chief Electronics Engineer,*
Central Research Laboratories,
RANK PRECISION INDUSTRIES LIMITED
Sulgrave Road, Hammersmith,
LONDON, W.6.

APPLIED RESEARCH

NON-DESTRUCTIVE TESTING.

STEWARTS AND LLOYDS, LTD.,

Department of Research and Technical Development, Scottish Section

PHYSICIST or ENGINEER

A qualified man is required to lead a section engaged in the application of non-destructive testing methods to steel tubes and manipulated pipework.

Candidates must possess a degree in Physics or the Diploma of Technology in Applied Physics. Familiarity with ultrasonic testing is essential, but experience in the field of sound reproduction or accoustical engineering might be acceptable.

A salary in line with present achievement will be offered. Staff Pension and Life Assurance Scheme in operation.

Written applications, giving full details of age, education, qualifications and experience, should be sent to

The Manager,
Personnel Services,
Clyde Office, Coatbridge.

SENIOR MICROWAVE ENGINEER

One of the most progressive electronics companies offers an outstanding opportunity for a man with the right qualifications to work in a pleasant and healthy seaside atmosphere yet within an hour's train ride from London.

The successful candidate will take control of a team engaged in the design of microwave components, duplexers and aerial systems. Qualifications up to degree standard, and experience in this field are essential.

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For an interview with the Manager of the Aviation Division, write to the Personnel Manager,

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SEMI-CONDUCTOR MEASUREMENTS AND APPLICATIONS LABORATORY

MULLARD SOUTHAMPTON WORKS

This is an advanced Laboratory which is rapidly expanding under the direction of Mr. E. Wolfendale. The aim of the Laboratory is to act as the basis for the Mullard comprehensive consultant service to industry on the application of transistors and associated semi-conductor devices. There are vacancies for

SENIOR AND JUNIOR ENGINEERS

capable of clear and logical thought in the solution of new problems in circuit techniques to work in the following fields:-

TELECOMMUNICATIONS
COMPUTERS
PULSE TECHNIQUES
INDUSTRIAL CONTROL

Experience of transistor circuitry is not essential as a well organised training scheme exists within the Laboratory designed to give a comprehensive introduction to the transistor.

Please apply in writing to the Plant Personnel Officer, Mullard Southampton Works, Millbrook Industrial Estate, Southampton, quoting the reference C.25.

"Mullard" is the Trade Mark of Mullard Ltd.

REMOTE SUPERVISORY CONTROL

Serck Controls is an expanding organisation developing advanced systems of digital electronic equipment which are rapidly finding acceptance in the oil, gas, water and electricity industries both at home and abroad.
Further staff are required to assist in the development of exciting projects.

DEVELOPMENT ENGINEERS

These should be in the age group 23-35 with a degree or H.N.C. preferably with a knowledge of logical techniques using solid state devices.

CONTRACTS ENGINEERS

These should be technically qualified and in the age group 25-35. Familiarity with instrumentation and/or communications and with an appreciation of an electronic approach together with an understanding of systems is essential. A facility for communicating ideas both personally and in writing is necessary. Opportunities for installation and commissioning work overseas may arise from time to time in the future.

TECHNICAL ASSISTANTS

These should be in the age group 20-30 and of O.N.C. (electrical or electronic) standard and should have the potential to become Engineers in the near future.
These appointments will be of interest to those who are prepared to work hard towards the achievement of clearly defined objectives as members of a team. Success will be rewarded both financially and by additional responsibility.
Applications to:—

SERCK CONTROLS
Parkfield House, Dorridge, Solihull
Warwickshire

ENGLISH ELECTRIC VALVE COMPANY LIMITED

Microwave Research and Development

The Company has considerable effort engaged on research and development into very low microwave tubes.

Physicists and Engineers are required to assist in this programme and whilst we would prefer graduates with experience in this field of activity, we would be pleased to hear from graduates with good Honours Degrees backed up with industrial experience in light electrical or electronic companies.

Employment would be at the Company's Works in Chelmsford, Essex.

Inquiries should be addressed to Group Personnel Services, English Electric House, Strand, London, W.C.2, quoting reference EE1506M.

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Experienced Radio and Television Service Engineers or Test Engineers with considerable experience in the testing of industrial electronic equipment are invited to apply for the above positions entailing the ability to test, programme and service Missile Telemetry and associated equipment. The work includes the testing of prototype equipment; the manufacture of test equipment and the servicing of commercial test gear, and is both interesting and varied.
The Division is situated on an airfield in rural Cheshire close to housing and shops and on main bus routes. A Superannuation scheme is in operation and there are good Canteen facilities.
Apply, quoting Ref. WRD/TD/R. 91/E to:

The Personnel Manager
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This Company wishes to provide a more comprehensive service to its customers in the industrial electronics field by the appointment of one or more additional senior Sales Liaison Engineers.

Applicants must be educated to at least H.N.C. level with experience in electronic or light electro mechanical systems design or development. In addition an ability to assess market potentials and to grasp commercial implications of new projects is essential.

This is a senior position, reporting directly to the General Manager, and applicants (30-45) must be able to produce evidence of a mature outlook in such work.

Salary by arrangement (car provided). Centre of operations—not necessarily Poole—can be decided after discussion.

Write, giving fullest details to:—

General Manager,

SIDNEY S. BIRD & SONS LTD.
Fleets Lane, Poole, Dorset.

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

requires a

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To assist in preparation of illustrated descriptive catalogues and specifications for electronic components and to serve on standardisation committees for such components.

SALARY: £1,060-£1,210 p.a.

Applicants should have served a recognised apprenticeship or have had equivalent training in electronic engineering.

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Send POSTCARD for details to **Personnel Manager (1906/42/.) U.E.A.E.A., A.E.R.E., Harwell, Didcot, Berks.**

BRUSH

(A member of the Hawker Siddeley Group—Industrial Division)

RESEARCH DIVISION

INDUSTRIAL ELECTRONICS

Sales Specialist Engineer

A Senior Engineer is required to act as Sales Specialist for a wide range of industrial electronic equipment which includes calculators, remote control devices, telemetry and a variety of instrumentation systems. Candidates should possess good academic qualifications and have had several years experience in both technical and sales fields.

Engineering Staff

Vacancies also exist for Senior and Intermediate Grade Research Engineers with at least three years experience of applied research in one or more of the following fields:—

Instrument Design
Pulse Circuitry
Digital Computers
Transistor Circuitry
System Design
Line Communication

Applicants for these posts should have at least a good Honours Degree in either Electrical Engineering or Physics. Where appropriate, appointments will be made as Section Leader or Group Leader.

The Company is situated on the outskirts of a small town, amid the pleasant Leicestershire countryside away from the smoky industrial environment. Schooling facilities are good for all grades of education, including advanced studies at technical colleges and universities in the district. In appropriate cases, assistance with housing and removal expenses can be considered.

Applications, WHICH WILL BE TREATED IN THE STRICTEST CONFIDENCE, should give details of experience and qualifications and be addressed to

Mr. A. Garner,
Brush Electrical Engineering Company Ltd.,
Loughborough, Leicestershire,

quoting reference: PL.9929.

ELECTRONIC ENGINEERS

for

Personnel Section

BMEWS

BALLISTIC MISSILE EARLY WARNING SYSTEM

The vital and challenging BMEWS project offers exceptional opportunities for well qualified electronic engineers with initiative and enthusiasm to branch out into the Technical Personnel Selection field. These are careers both of importance and very great interest, and involve assisting the Senior Technical Personnel Officer in the recruitment of Electronic Engineers and Technicians.

The men we choose will receive every assistance in familiarising themselves with the various aspects of their work, which includes all facets of staff recruitment, particularly sources of recruitment from industry; job evaluation to determine the type of men needed; classifying applications, interviewing candidates and assessing their potential.

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These careers carry generous salaries according to responsibility.

Please write briefly, quoting ref. POTS, to:—

The Personnel Manager, Special Projects Division,
R C A GREAT BRITAIN LIMITED
AN ASSOCIATE COMPANY OF RADIO CORPORATION OF AMERICA
Lincoln Way, Windmill Road, Sunbury-on-Thames Middlesex.

ELLIOTT

ELECTRONIC ENGINEERS

Vacancies exist in our High Voltage Tube Division for Qualified Electronic Engineers able to design test and measuring equipment required for the development of specialized high voltage electron tubes.

Applications should be addressed to:
The Personnel Manager (Ref. 326),
ELLIOTT BROTHERS (LONDON) LTD.,
Elstree Way, Borehamwood, Herts.

MANAGING DIRECTOR

Manufacturers of electronic instruments in the U.S.A. now establishing a manufacturing facility in the U.K. invite applications for the position of Managing Director. A degree in engineering or equivalent professional qualification and previous management experience in a medium-sized company are essential. Preferred age is 35-45 and applicants must be willing to undertake training in the U.S. Applications are also invited for engineering and technical posts. *Reply in confidence to:*

MR. WILLIAM P. DOOLITTLE
HEWLETT-PACKARD S.A.
RUE du VIEUX BILLARD No. 1
GENEVA, SWITZERLAND

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electronics

A Company, well-known and expanding in the electronic field, has established a group of engineers to develop Static Power Conversion devices, and requires a Project Leader to control and expand this team.

Electronic engineers are invited to apply for this position, which demands ability to inspire and lead, together with technical competence of a very high order in this field.

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The prospects of further advancement for the selected applicant are excellent.

Please reply, giving full details, to Box No. W.5099.

GRANADA TV

are establishing a Design and Development Section in Manchester. Applications are invited for

ENGINEERS

in a number of posts who have had experience in some or all of the following fields of television, radio frequency, pulse circuitry and the application of transistors to communications work generally.

The Company operate a 5-day week and have a generous Pension and Life Assurance Scheme.

Applicants should write giving details of qualifications, experience and present salary to Norman Price, Personnel Manager, Granada TV Network, Limited, Manchester 3.

LONDON
CROSFIELD
ENGLAND

ELECTRONIC ENGINEERS

for transistor and valve circuit design of Electronic and Optical-Electronic equipments for use in interesting industrial applications. These rewarding posts are open to conscientious and hardworking men with qualifications and experience in this field. Do not hesitate to write in confidence to us if you consider yourself a suitable candidate.

CHIEF ENGINEER,
GRAPHIC EQUIPMENTS DIVISION,
J. F. CROSFIELD LTD.
2 Elthorne Road, London, N.19

ICI

METALS DIVISION

A SENIOR INSTRUMENT DEVELOPMENT ENGINEER

is required to lead a team of Engineers and Draughtsmen in the Metals Division Engineering Department at Witton, near Birmingham.

Candidates, preferably in the age range 30-40, should have a degree in Physics or, possibly, light Electrical Engineering. Knowledge of the light electrical field of automatic control, non-destructive testing of materials or some experience of the general field of industrial instrumentation will be an advantage.

There is an attractive starting salary with prospects of advancement. There are Profit-Sharing and Staff Pension Fund schemes in operation. Assistance can be given towards house purchase and removal expenses for a married man.

Please write for an application form to the:—

Personnel Manager (Staff),
IMPERIAL CHEMICAL INDUSTRIES LIMITED,
Metals Division, P.O. Box 216, Kynoch Works,
Witton, Birmingham, 6,

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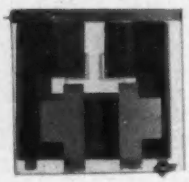

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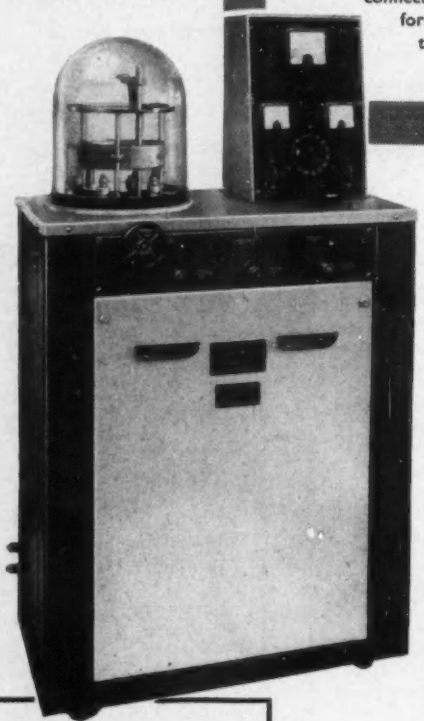

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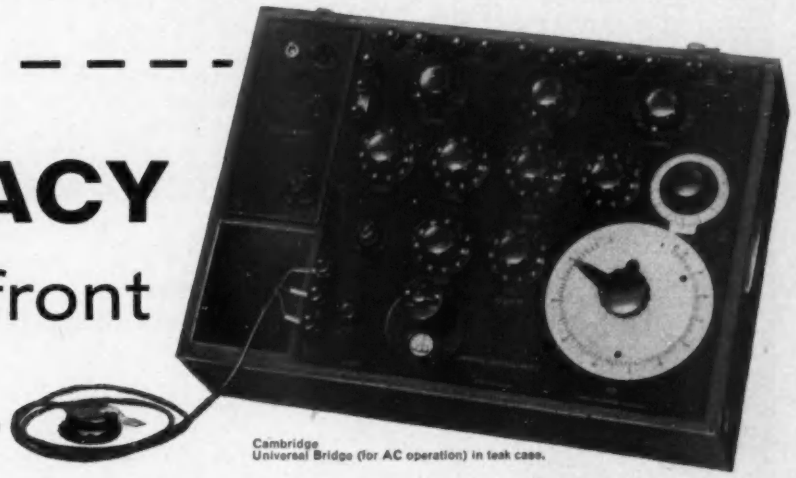

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Printed in Great Britain by The Press at Coombelands, Ltd., Addlestone, Surrey, for the Proprietors, Morgan Brothers (Publishers), Ltd., 28, Essex Street, Strand W.C.2.
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